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AN ANALYSIS OF THE COMPETITIVE STRATEGY IN THE INDUSTRY PROVIDING A DEFENSE SYSTEM OF SYSTEMS

by

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December 2000

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ABSTRACT

The change from platform to network centric warfare requires new perspectives of the Defense Industrial Base. Both the 1996 Defense Science Board Report on Vertical Integration and DoD's 1999 report on Price Based Acquisition recommend that DoD take steps to further understanding of competitive conditions in the defense industry. This thesis explores one method for gaining this insight. The industry is producing the system of systems for DoD, not just platforms. This thesis studies prime contractors for 78 programs which have been determined as the foundation for the future system of systems. By applying the Value-Net business model, it reviews the influences the Department of Defense, International Governments and industries, commercial firms, and suppliers have upon the prime contractors. This analysis identifies growth markets in interoperability development and open system component development. It also identifies competition-induced constraints on weapon system production markets. Through a survey of Defense Contract Management Agency Prime Integrators, it determines the concentration of prime contractor performance in the 78 programs. Based on data from 61 of the 92 prime contracts, it also reveals performance trends , indicating that key players in the industry have established strategies for network centric development. This thesis also shows that using the Value-Net business model is a valid method for understanding competitive influences in the industry for network centric warfare

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I. INTRODUCTION

A. BACKGROUND

In May 1997, the Defense Science Board Task Force reported on Vertical Integration and Supplier Decisions. The study looked at industries that produced integrated defense systems such as tanks, aircraft, ships, satellites and the subsystems and components needed to build them. [Ref. 36 p. vi] One of the five recommendations made by the Board called for the establishment of measures to "help DoD managers recognize areas of potential vertical integration concern and trigger more detailed investigation." [Ref. 36 p. xv] This recommendation was qualified by a caution that the diversity of the technology and platforms make a universal measure of integration impossible and undesirable. Statements made by Robert Pitofsky, Chairman of the Federal Trade Commission, in July of that same year also voiced concern that the focus of competition analysis is at the system level. "The Commission may need to look at a number of potential markets in any one merger. For instance, if both merging firms make missiles, aircraft, and submarines, the Commission would look at all three of those weapons systems to see if they qualify as relevant product markets." [Ref. 75 p.3] The Department of Defense and the Federal Trade Commission's focus on platform producers is aimed at an extremely important segment of the industry. Recent changes in the Department of Defense, however, require a view of the industry from a higher level.

The Department of Defense formalized initiatives during the 1990's that have a profound effect on Mr. Pitofsky's statement. Just a few months before the Defense Science Board published its report, and Mr. Pitofsky made his statements, Joint Vision

2010 was published. This vision has developed into the concepts of network-centric warfare and a defense system of systems. These concepts place the value of the system at its ability to integrate within the battlespace. Through JV2010, network-centric warfare, sensor-to-shooter concepts and now time-critical targeting, the Department of Defense has been shaping its vision of future integrated warfare systems. The Joint Staff best summarizes the defense industry's message to industry when it explains how JV 2020 supports the four operational concepts employed by the armed forces.

> The new document focuses on three factors as central to success in these four operational concepts and the resulting capability of full-spectrum dominance:
>
> Interoperability: Success across the full range of military operations requires interoperability among the joint force, multinational partners, and the interagency.
>
> Innovation: Broad-based innovation is the key to transforming the capabilities of the joint force.
>
> Decision Superiority: Information superiority will enable joint command and control to be transformed so our commanders can make better and faster decisions than their opponents. [Ref. 69]

The Department of Defense is publicizing that desired future systems will operate in the synergistic overlaps between Detection, Communication, and Execution. This thesis uses the conceptual model from Lifting the Fog of War by Admiral William Owens (US Navy, Retired) to demonstrate the emerging operational domain. [Ref. 79 p. 99] Because of this emergence, the relevant market for firms is the DoD's integrated system of systems that the prime contractors' products support.

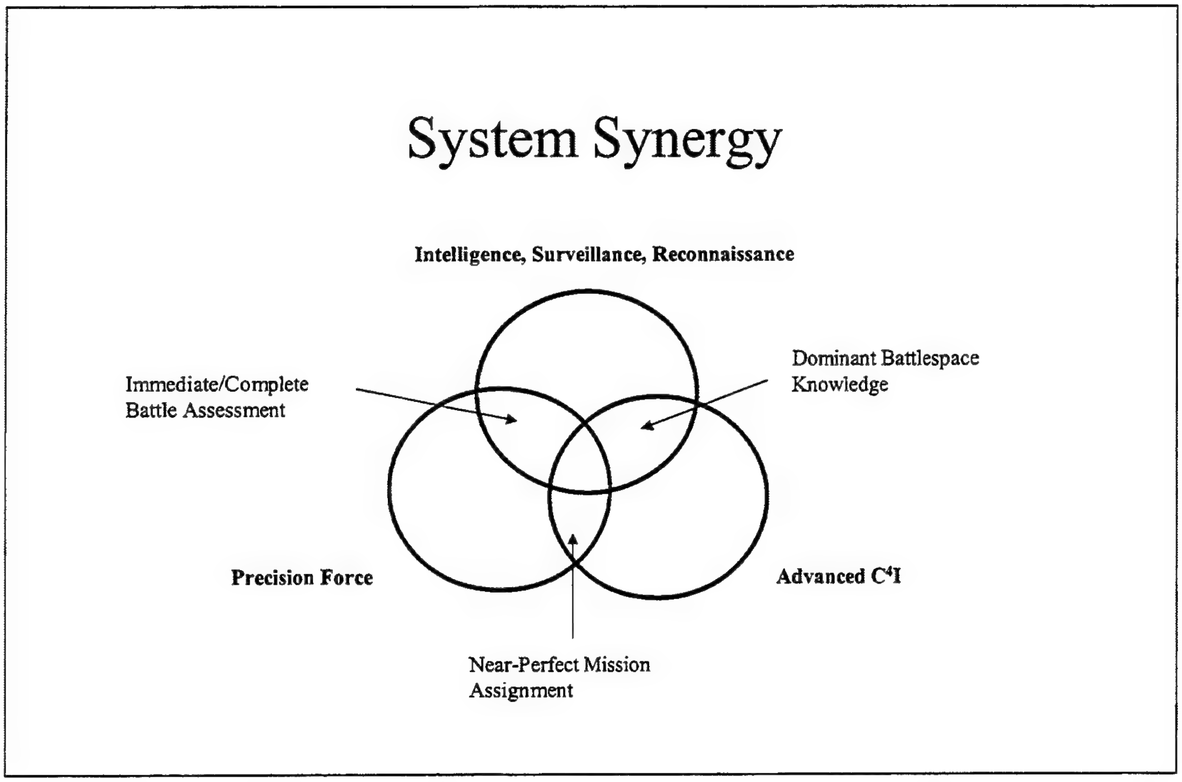

Figure 1 System Synergy From [Ref. 78 p.99]

While military doctrine proposed network power and system compatibility, the Acquisition and Science and Technology initiatives promoted single system and component optimization over systems integration. In the early 1990's, the Department of Defense was coming to grips with its reduced budget. While Federal resources applied to research and development were shrinking, civilian expenditures in this area were growing. In the face of these reduced R&D resources, the Department of Defense moved to optimize individual platform and component performance by leveraging ongoing commercial R&D efforts. The Department of Defense took measures to instigate spin off and spin on initiatives. Acting on the recommendations of the Carnegie Commission, The Department of Defense dropped the term "Defense" from DARPA and refocused its

emphasis on dual use as well as defense unique technology. [Ref. 84 p. 17] In 1993, the Technology Reinvestment Project (TRP) was unveiled. Additionally, In June of 1994, then Defense Secretary William Perry signed his directive abolishing military specifications without special approval. Acting on the recommendations from the process action team for acquisition reform, he set a course to promote systems design and development based on commercial standards and performance specifications. These initiatives placed the onus on Defense Industry to balance the infusion of technology with the optimization of the systems of systems. Since the money was aimed at platform optimization, and network warfare was still a concept, system of systems integration did not receive proper industry attention. This method of acquisition, however, produced exceptional platforms that can provide tremendous sensor information to the commander and eventually to the engaged weapon system. The growth of capability resulted in an explosion of communication pathways. As an example, the following two figures demonstrate the communication networks available to a Naval asset during the Gulf War and Today. [Ref. 40]

Because of the focus of this analysis, the titles and individual transmission speeds of the systems listed in these figures are irrelevant. The relevance of these diagrams is in the sheer volume of communication systems and overall data rate used in Naval operations. These figures show how the naval commander can turn to multiple systems to gather independently developed pieces of the battlespace picture. The systems were not designed to synthesize their products, and therefore, do not produce a single commanders' picture without considerable data manipulation. Nonetheless, the information has become available and although cumbersome has created an inter-system

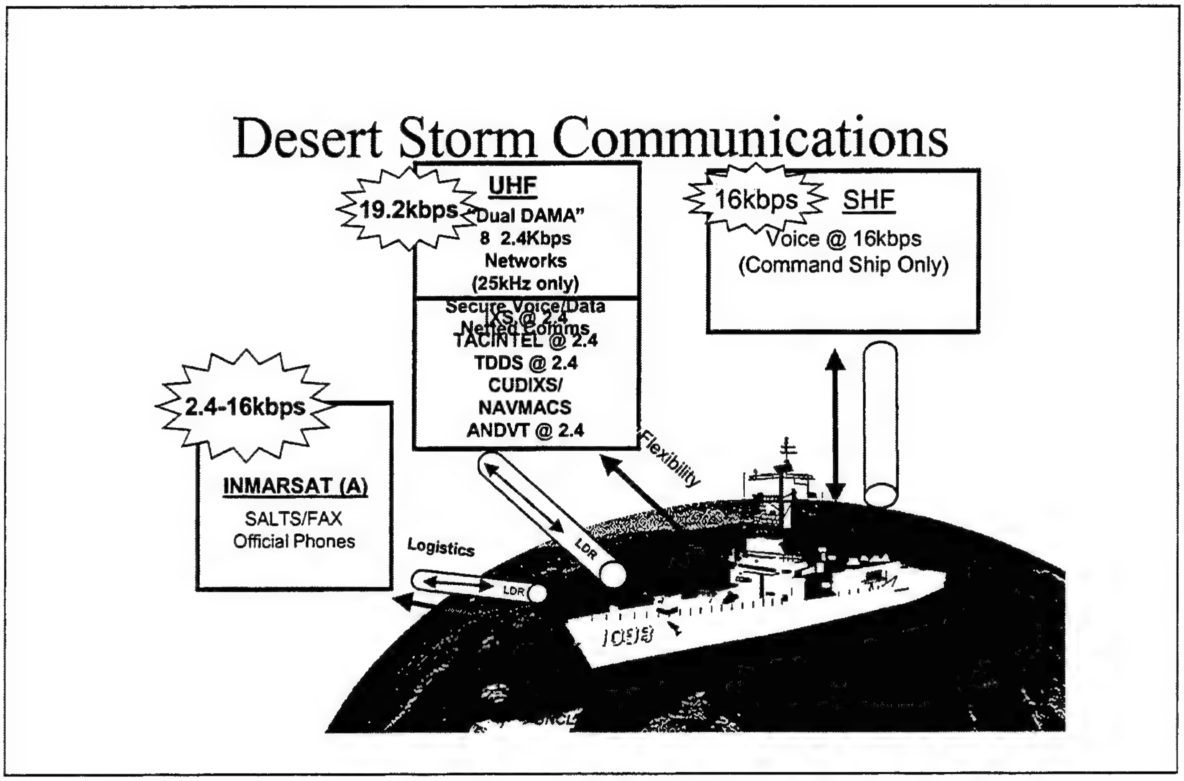

Figure 2 Desert Storm Communications From [Ref. 40]

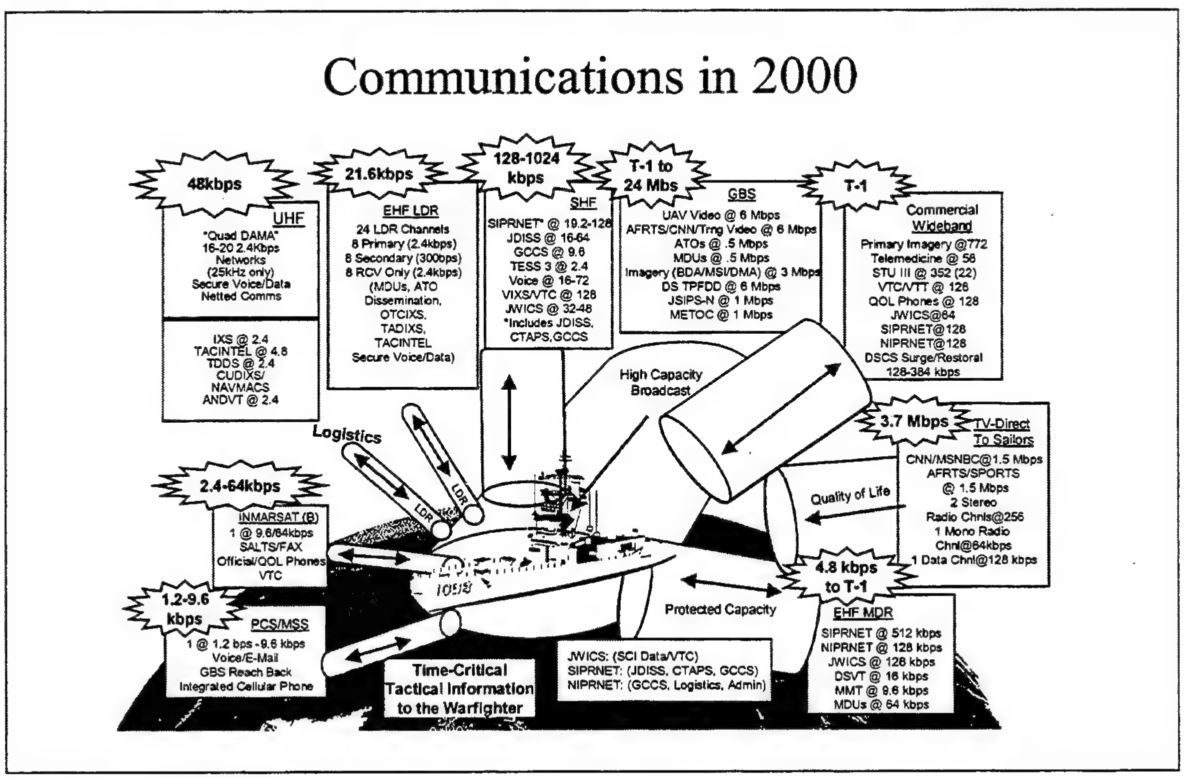

Figure 3 Communications in FY 2000 From [Ref. 40]

dependence. This growth of interdependence gave credence and empirical validation of the networked warfare concepts.

The Department of Defense's shaping of the industry through commercial and interoperability requirements has additionally created global consequences. The globalization of the technology base is having a tremendous impact on weapon system development. In 1997, the National Defense Panel described the technology base for future defense systems as increasingly global and commercial. [Ref. 37 p. 74] The defense industry firms must compete at a global level because the technology market crosses national borders. Benjamin W. Heinman, Jr., Vice President General Electric Company, in his 1995 testimony on the global an innovation based competition stated, "The markets in which new technologies are developed and in which products are sold are international rather than national in scope. ... In sum, it is obvious to those of us engaged in the day-to-day global competition that the winners in the world marketplace will be firms and nations that create the lowest cost, highest values products in the quickest, most efficient manner." [Ref. 29] As defense systems become increasingly dependent on technology and innovation, the global influences will have a greater impact on the Defense Industry. Additionally, events in Kosovo showed that the interoperability requirements are no longer restricted to US forces. Future warfare is expected to to be predominantly coalition warfare. In his June 1999 speech to seventeenth NATO workshop, Dr. Jacques S. Gansler stressed that interoperability will be the requirement for all future conflicts. He also defined how interoperability would be maintained.

> That said, technology -- when proper coalition planning and implementation are achieved -- enables us to act effectively -- in fact, synergistically -- to achieve the objectives we seek. But it does require that each partner keep up with the technological evolutions; an admittedly difficult and an expensive effort – including both the investment in new military equipment and in the training for its use, as well as the continued investment in research and development in order to stay ahead. [Ref. 42]

The integration initiatives of the late 1990's have given the networked warfare concept an increased importance and therefore raised the importance of complementing and interoperable systems. The Secretary of the Navy and the Defense Undersecretary for Acquisition Technology and Logistics have both established Interoperability Directorates. In 1999, Dr. Gansler and General Joseph W. Ralston established system interoperability as a key performance parameter in all future Operational Requirements Documents. "To accomplish this goal, the Joint Chiefs of Staff have already completed a rewrite of the Chairman's "3170 Series" to reflect flexible and time-phased requirements, interoperability as a key performance parameter, the use of capstone requirements documents for mission areas, and affordability in requirements documents." [Ref. 43 P. 14] Additionally, the 2001 Defense Authorization bills, H.R. 4205 and S. 2550, both include section 906 which is titled Network Centric Warfare. This section directs the Department of Defense to study and report on network centric warfare. The report due in October 2001 shall make recommendations for the acquisition, development, and execution of network centric warfare. This language is accompanied by line item in the conference report 106-644 that allots $9 Million "to develop the Naval Fires Network Demonstrator, test the tactical dissemination of intelligence for Time Critical Strike

Capabilities on-board the E 2C, and refine the NCW concept of operations". [Ref. 86 p. 167]

Recent alliances and changes in the industry suggest that the large defense firms may be making strategic moves to capitalize on the Department of Defense interoperability initiatives. Lockheed Martin has announced a business alliance with Cisco Systems as a means of enhancing their networking capability for systems such as DD-21 and the US Air Force's Integrated Space Command and Control (ISC2) requirement. [Ref. 76] They have additionally announced development of the JSF high-fidelity sensor integration facility outside the Dallas Fort-Worth airport. [Ref. 77] The competitive strategy of firms integrating the sensor to shooter systems may be the common denominator of the diverse market environments described by the Defense Science Board and Mr. Pitofsky. If the members of the industry are building their corporate strategy around providing sensor to shooter or networked systems, they would compete for a platform or capability based on its relevance to the larger system of systems and their position in the industry.

B. OBJECTIVE

The objective of this thesis is an analysis of the Government/industry relationship that will produce the weapon systems of network centric warfare. It will examine the incentives of Government policy, market forces, and structure. The focus is on the influence of structure as a means of promoting or inhibiting competition, efficiency, and innovation. Subsidiary research questions include:

1. What is the competitive environment for prime integrators developing a defense system of systems?
2. How does the globalization of technology industries affect the competitive environment?
3. How do Government forces shape industry structure, FTC regulation, and DOD incentives?
4. What is the market structure in terms of maturity, differentiation or economies of scale opportunities, and exit and entry costs?
5. Given the above industry shaping forces, what economic principles and models may be used to predict industry activity?
6. Given the predictions, are there recommendations for Government action that may influence industry structure?

C. SCOPE

This thesis examines the 78 acquisition programs for platforms and systems that equate to the Department of Defense's near term networked warfare capability. The warfare capabilities are categorized in four mission areas.

1. Theater Area Defense
2. Operational Maneuver From The Sea
3. Dominant Maneuver
4. Precision Strike

The selection of these mission areas and programs are based on an analysis of three reports:

1. Tecolote Report 1995 Sensor to Shooter Costs
2. Overview of C4I systems by NRAD 1997
3. US Force Designs and TO&E for 2000 RMA Wargames Force by SAIC Corp

This thesis examines the prime integration contractors of these programs. The analysis plots the contractor participation in terms of presence, percentage of revenue, and value added based on the vision of the networked system of systems. The data is collected from government contracts databases, contract administration facilities the

Defense Contract Management Agency (DCMA), and recent internal financial and strategic planning as determinable by stockholder reports, public affairs announcements, and security exchange commission required reports. The research explores and describes the range of influences on these firms through an analysis of Government trends and domestic and global competition activity in the defense and commercial sector.

D. METHODOLOGY

This thesis uses Admiral Owens' model of warfare to define industry involvement in the development of the missions listed above. The research performs a value analysis of the external influences on the defined industry. This analysis is based on a Value-Net model developed by Harvard Business School and Yale School of Management economists Adam Brandenburger and Barry Nalebuff. [Ref. 8] This model applies the principles of game theory to the well-accepted Porter model of competitive forces. It provides a useful structure with which to analyze the desired value, complements and competition in a contract relationship. In building the model, this thesis first defines the external influences through literary research of Government technical reports and congressional documents focused on the attributes of network-centric warfare, time critical-targeting, open systems architecture, and interoperability requirements. It then analyzes the forces internal to the industry by researching the concentration of value added networked warfare production capabilities of the prime contractors for the 78 programs. This research focuses on the complementary attributes created by the industry's most recent structure and the networked warfare concept requirements. The research then applies industrial organization principles to the established structure.

E. THESIS OUTLINE

Chapter II has two objectives. First it defines Network-Centric warfare and its critical acquisition requirements. Building on the definition, it applies Admiral Owens' theories to the Department of Defense's recent initiatives and validates the programs selected for this thesis. Second it describes the merits of the Value-Net paradigm and how its features suit this analysis. It explains how the oligopolistic attributes of the Defense industry are defined by game theoretic principles. Then it shows how the understanding of complementary and competitive forces is a crucial element of understanding the associated strategic interaction that occurs. The third chapter defines the Government/Industry Value-Net. It describes the characteristics of each node in the Net and its possible interaction with the rest. The fourth chapter analyzes the relationships defined in chapter three with industrial organization and economic analysis. The final chapter draws general principles that may be applied to the defense industry in terms of the Revolution of Military Affairs and Network-Centric Warfare.

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II. METHODOLOGIES

A. NETWORK CENTRIC WARFARE

1. Introduction

The Revolution of Military Affair's vision of smaller, swifter forces relying on information superiority for success is certainly different from the massing of forces doctrine proposed by Carl Von Clausewitz and perfected by the war experiences since Napoleon's Levee en Masse. It is different, but not contradictory. Both Clausewitz and Sun Tzu professed that awareness of the battle environment and one's own capabilities were crucial to a commander's success. Clausewitz called all the interdependent aspects of the battlespace friction and stated that "a good general must know friction in order to overcome it whenever possible, and in order not to expect a standard of achievement in his operations which this friction makes impossible." [Ref. 17 p. 120] Sun Tzu summarized the use of information into "Know the enemy and yourself; in a hundred battles you will never be in peril" [Ref. 98 p. 83] Both Clausewitz and Sun Tzu believed that although battlespace awareness was crucial to successful operations, the assessment and communication technology of the time made accurate and timely information impossible. Sun Tzu suggested deception as a way to use poor information to your advantage; Clausewitz advocated the use of overwhelming force to overcome the effects of poor information. Existing sensor and communication technology makes network centric warfare possible. Assessment and communication systems of the near future

promise to be sufficiently reliable, swift, and accurate enough to negate friction, penetrate the fog of war, and discern the true objectives of a deceptive enemy.

Dr. David Alberts and Mr. John Garstka through the C4ISR Cooperative Research Program (CCRP) propose that the concept of Network-Centric Warfare, although not a panacea, is a means to improve our current performance and gain a superior level of battle awareness. [Ref. 2 p. 11] Dr. Alberts' position as the special assistant to the Assistant Secretary of Defense (C31) and the Director, Research and Strategic Planning and Mr. Garstka's position on the J-6 staff are signs of the support the network centric concept has gained in the Pentagon. The concept of Network-Centric Warfare uses Information technology, distributed operations, and a flexible "infostructure" to leverage warfare capabilities in the battlespace. The foundation for network centric warfare is the efficient use of information. First, sensors must gather the information, and then command and control assets must analyze and transmit the information. Finally, forces and weapons systems must use the processed information to execute the mission. In platform centric warfare, this process is sequential while network centric warfare proposes near simultaneous performance of the three functions. Network centric warfare creates power and value through the speed, accuracy, and robustness with which the all elements of the military force form the battlespace picture.

Clausewitz explained that the difficulty in achieving a military objective is that the commander has a different insight into the battlespace than his subordinates, which results in opposition and an inertia that must be overcome before success. [Ref 16 p. 580] The tremendous amount of information being transmitted in infinitely shorter amounts of time is changing this view. The speed with which differing views of the battlespace can

be resolved is the impetus for the shift to network centric operations. Dr. Alberts and Mr. Garstka have observed companies such as Wal-Mart and Cisco Systems using shared information to create a dominant position in their competitive market place. They propose that networking the systems performing the three-steps of a mission will have the same benefit for military forces. Furthermore, they subscribe to Metcalf's law that the potential value of a network increases by the square of the number of nodes connected. [Ref. 2 p. 250]

Admiral Owens focuses on the potential value of networks when he states the payoff from the Revolution of Military Affairs is in the overlaps of the three steps of a mission. These overlaps of the function areas are the interfaces through which information is shared. The platform-centric model places the sensor, command and control systems, and offensive weapons on brilliant, expensive, and virtually independent systems. The systems are often unbalanced in that the weapons can shoot farther than the platforms sensors can see, or the sensors do not provide data sufficiently robust to create a fire solution. The network-centric model proposes to correct these mismatches through fusion of targeting, environmental, and situational information collected from multiple sensors into a coherent battlespace picture. Additionally, this picture would be available to all units. The commander would be able identify a target, select a platform and execute prosecution using any combination of available platforms. [Ref. 44 p. 1] The key difference between the network-centric and the platform-centric process is that the network-centric process works on the principle of single data entry. Once a sensor picks up a target, all other assets on the network have visibility and access to the information for processing and action.

With all the communication links available to commanders, the information for a complete battlespace picture is arguably available now. Admiral Cebrowski, however, emphasizes that information superiority and the value of relationship depends not only on the availability of the data, but that "there is value that is derived from the content, quality, and timeliness of information moving between nodes on the network. This value increases as information moves toward 100% relevant content, 100% accuracy, and zero time delay—toward information superiority. [Ref. 12] The platform-centric organization requires each unit to receive process and package information before transmitting it to other assets. The network-centric model allows all assets to simultaneously, receive, fuse, process and decide upon all data in the battlespace. It maximizes the interfaces between platforms. Admiral Owens stated that network-centric warfare works through the value generated by linking exceptional systems. "Merging our increasing capacity to gather real time, all weather information continuously with our increasing capacity to process and make sense of this voluminous data builds the realm of dominant battlespace knowledge (DBK)." [Ref. 79 p. 4]

2. The Network of Programs

In making network centric warfare a reality, Dr. Alberts states that development process must follow four principles of co-evolution.

1. Continuous user involvement
2. Use of rapid prototypes to allow users to get tangible representations of the future;
3. Build-a-little, test-a-little philosophy; and
4. An architecture that accommodates the changes that will surely come. [Ref. 2 p. 208]

These principles of development are at the heart of the revised DOD Directive 5000.2 effective 23 October 2000. The acceptance of iterative development suggests there will not be a leap but an evolution from platform centric systems into a network centric system of systems. The evolutionary process means that platforms in use today will be the base from which industry will develop the infostructure for tomorrow. The researcher relied on this assumption when he sought out current programs that either have been established as part of the system of systems, or are being specifically designed to satisfy the requirements of network centric warfare.

Although linkages between systems will actually be made at the component level, this thesis asserts that the industry produces integrated weapon systems, not components. This research, therefore, focuses its analysis at the networked systems not their components. For example, the radios and radars of the F-22 will transmit to the processing computers of Aegis ships and the Common Ground Station (CGS), however, the Operational Requirement Document (ORD) and the Mission Needs Statement (MNS) call for an interoperable aircraft not a flying radar and radio system.

The 1996 Tecolote report on Sensor to Shooter networks evaluated costs of over 100 systems that the team considered critical to effective operations. The report classified the mission requirements of the systems or nodes of the network into six Operational Situations OPSITs:

1. Suppression Enemy Air Defenses (SEAD)
2. Close Air Support (CAS)
3. Precision Strike
4. Dominant Maneuver

5. Operational Maneuver from the Sea (OMFTS)

6. Theater Air Defense

This Thesis combines SEAD, CAS, and Precision Strike into "Precision Strike". The Observation, Orientation, Decision, Action (OODA) loops for these missions are essentially the same, although SEAD and Precision Strike against mobile targets require shorter cycle times. Operational Maneuver from the Sea and Dominant Maneuver are separate because of the coordination with naval assets required in OMFTS demand an added level of networking.

Starting with the 100+ programs identified by the Tecolote report, the researcher assessed the current literature of network-centric warfare concept papers, wargaming documentation, and C4I structure reports to update that list. The literature review identified programs canceled since Tecolote issued the 1996 report and added programs that have started since. The systems are presented in Admiral Owens' three-lobe diagram of mission functions. When a platform can perform more than one function, the researcher placed it in the lobe of its primary functionality.

In network centric warfare, the sensor and communication systems will not be restricted to a mission type. Commanders use the Predator UAV system to provide sensor information to an aircraft on a precision strike mission as well as a Bradley fighting vehicle performing a dominant maneuver. Many sensors and almost all of the communication systems are used in more than one operational situation. The versatility of these systems is evident in the number of diagrams within which they appear. Since the weapon systems analyzed were developed for platform centric warfare, they almost all have capabilities in multiple function areas. For example, the F/A-18 has onboard sensors

and communication equipment as well as the capability to execute a weapons delivery. To simplify analysis, the researcher selected a primary function for each platform. Not every sensor could be a shooter, but every shooter would be able to provide information for the network. Mapping the potential relationships demonstrates the extent of interdependence between the systems. The goal of this thesis is to demonstrate that this system interdependence is influencing industry structure. An analysis of the depth of interdependence is beyond its scope. The system of systems for each of the four operational situations is listed below.

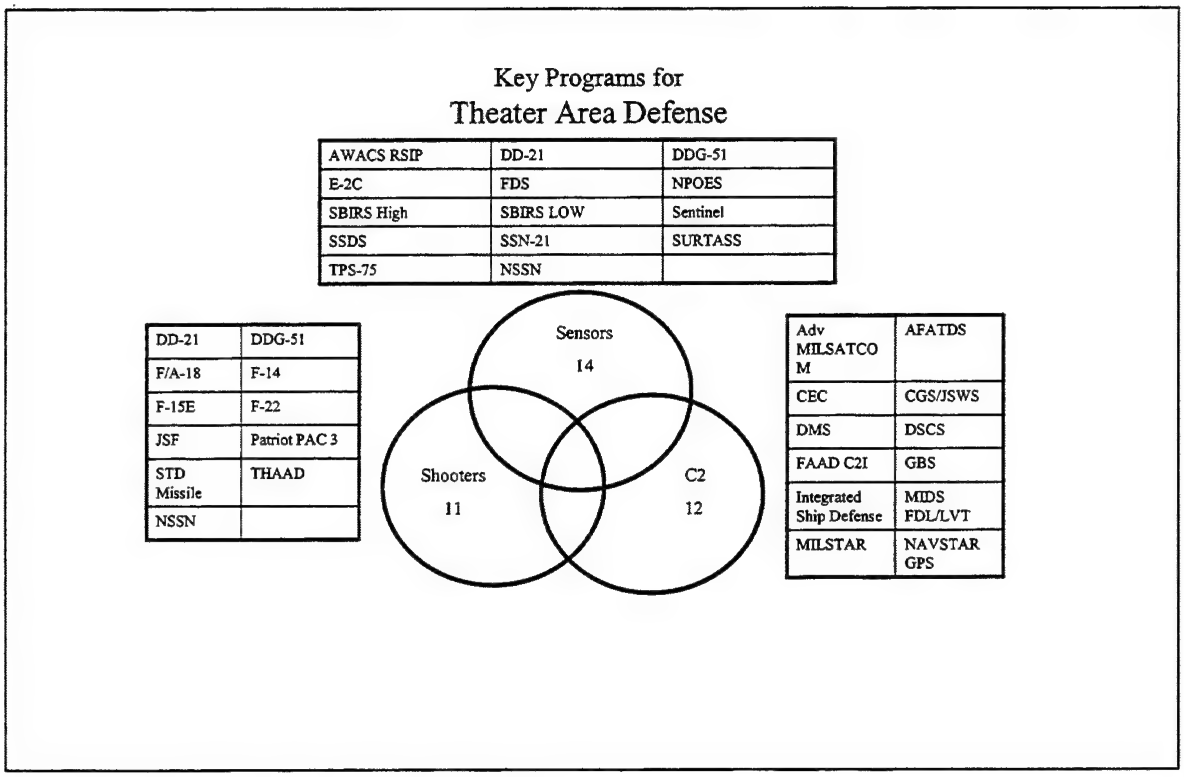


Figure 2 TAD Programs Developed by Researcher

The researcher expanded the Tecolote Operational Situation (OPSIT) for Theater Air Defense to Theater Area Defense (TAD) by the addition of the undersea battlespace.

Although network centric examples focus on time-constrained air defenses, the government expenditures in undersea warfare warrant its addition in the study.

The RDT&E Programs (R-1) exhibit of the FY2001 defense budget contains twelve program elements totaling $232 million that expressly identify undersea surveillance and defensive systems. The Procurement programs (P-1) exhibit expressly lists 25 program elements totaling $205 million. Additionally, SSN 21 is a $13.2 billion program and in 1998, the Naval Sea Systems Command placed a $4.2 billion order for four NSSNs.

The addition of the undersea battlespace only added sensors to the OPSIT's network. First, at the level of this study, it seems appropriate to assume that undersea data transmissions share bandwidth on government telecommunication satellites. Second, although the NSSN and SSN-21 platforms perform multiple functions in potentially three operational situations, the researcher classifies the platform as an undersea surveillance system for the network. [Ref. 31 p. 46] The strike capability is the Tomahawk missile system, which the researcher evaluates independent of its launching platform. The platform's offensive undersea weapons (torpedoes) do not rely on targeting data other than what onboard sensors provide. Finally, the TAD mission does not include the Ballistic Missile Defense System. The system is not addressed because its components are primarily the platforms listed. BMD and NMD are the system of systems in the Tecolote report's theater air defense OPSIT. [Ref 30 p. 63]

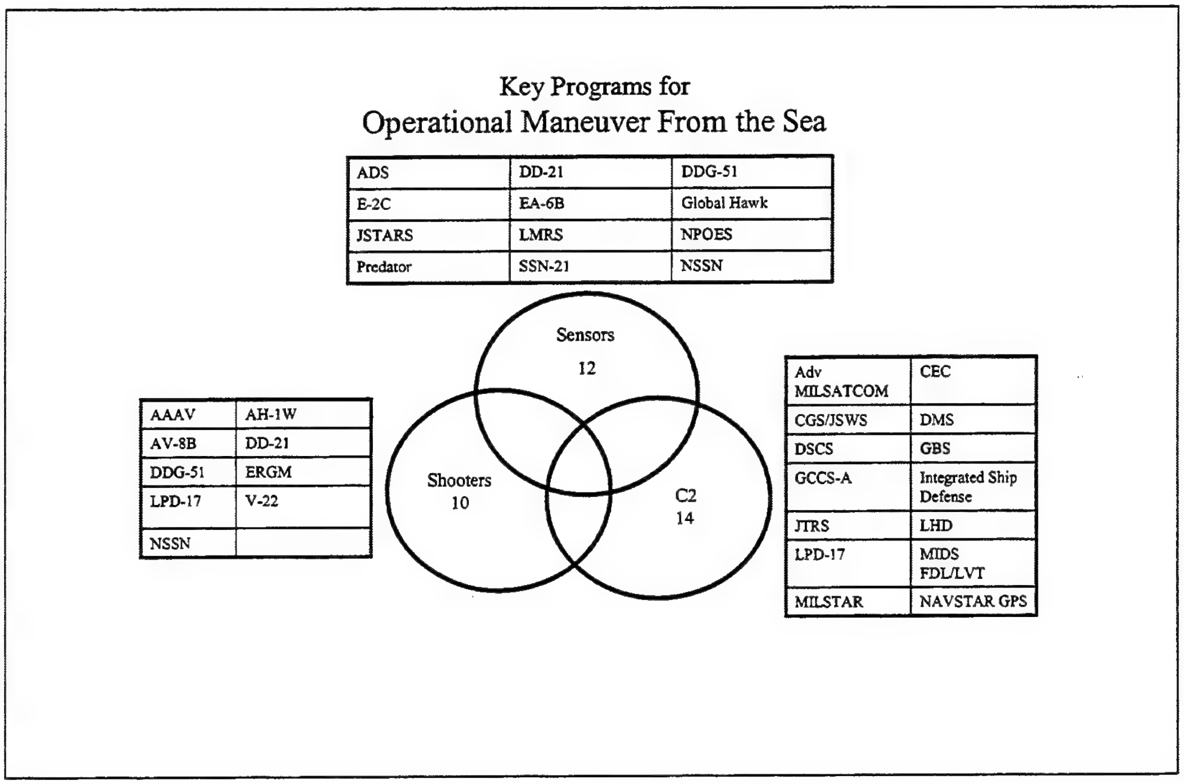


Figure 3 OMFTS Programs Developed by Researcher

As stated above, the researcher considers Operational Maneuver From The Sea (OMFTS) a unique operation because of the battlespace complexities when moving across the littorals to the objective. The objectives of OMFTS require dominant knowledge of the air, surface and undersea environment. The evolution of network centric systems for OMFTS operations, therefore, will emphasize the interoperability of systems managed by all the services. This separate OPSIT additionally allows for an analysis of the Navy's investments in amphibious assets

The title "swarming" comes from the US Force Designs and TO&E prepared for the QDR wargames. Swarming is "the employment of small, fast, lethal ground combat

units *which* enable the friendly force to use maneuver to effect fires with great agility" [Ref. 73] The wargames project a force for 2025. The vehicles that will deliver fire at the speed demanded by the swarming concept are of a revolutionary design. The electronic systems linking these vehicles to the network, however, are evolutionary. Each of the armored programs listed above are going through upgrades or development enhancements that increase connectivity. The evolutionary development of the swarming concept establishes the requirement for the listed programs in this study.

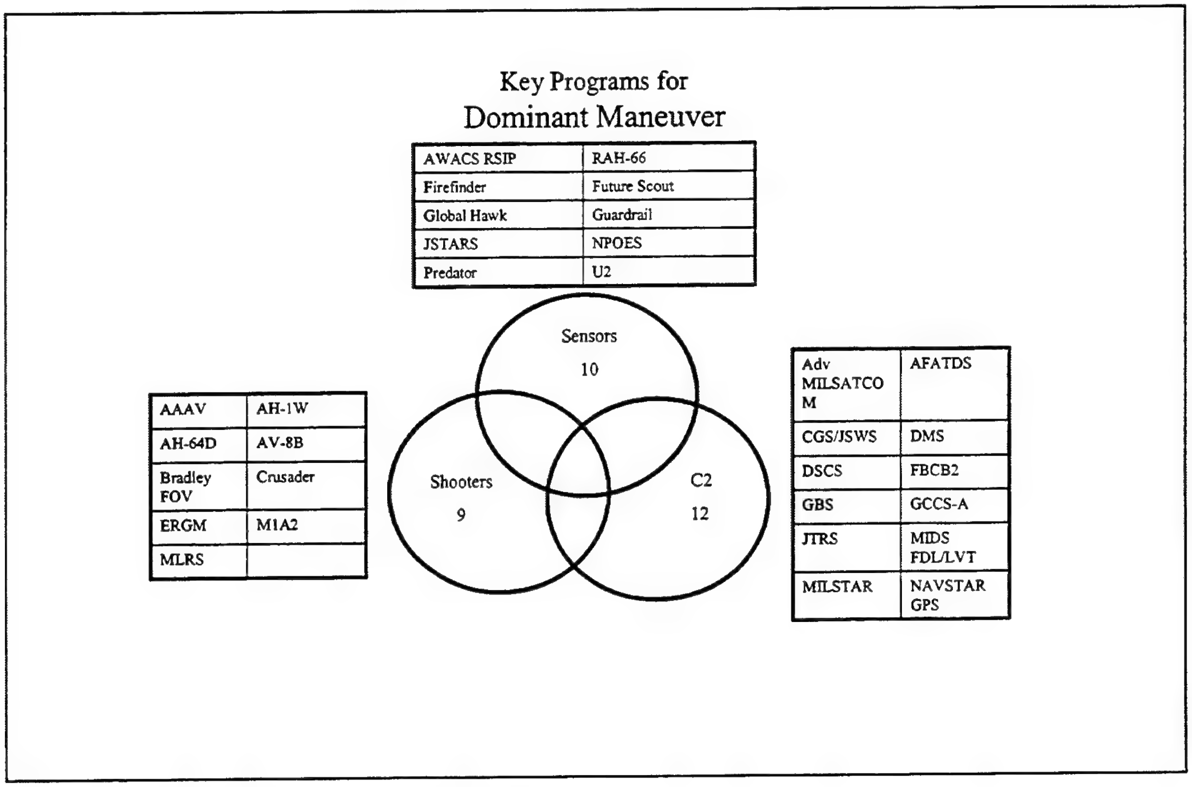


Figure 4 DM Programs Developed by Researcher

The precision strike elements are the most discussed aspects of network centric warfare. Real time information to the cockpit and time critical targeting are network centric solutions to a slow OODA loop compared to the speed with which mobile targets move. The tight coupling between the sensors onboard the aircraft and the performance of

Unlike the submarine, the pilot of the aircraft can fire the weapon on target information passed to it by an E-2C or some other sensor platform. The aircraft's systems must therefore be able to communicate with the command and control aircraft as well as direct the missile. It is the infostructure for weapons such as the JSOW and JDAM.

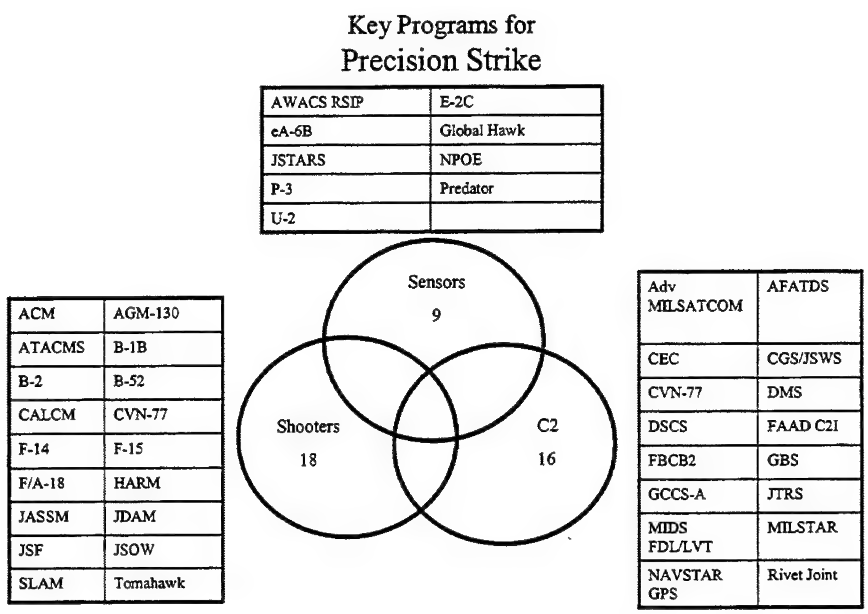


Figure 5 PS Programs Developed by Researcher

The contracts between the Department of Defense (DoD) and the prime contractors establish the terms of the supplier/buyer relationship for network centric capabilities. This thesis focuses on the value added or integration work performed by the prime contractors. Therefore, although the programs have diverse engineering and component requirements, the scope of the industry is focused on a single capability. DoD (the customer) is seeking the synergy of systems. The scope of the industry is therefore

firms who manage the integration of components within systems and interoperability between systems.

B. THE VALUE NET

1. Introduction

Adam Brandenburger of the Harvard Business School and Barry Nalebuff of Yale are co-authors of the book "Co-opetition.", which introduces the Value-Net as a view of the business environment through concepts of game theory.[Ref. 8] The application of game theory forces a merging of the cooperative and competitive views of business arrangements.

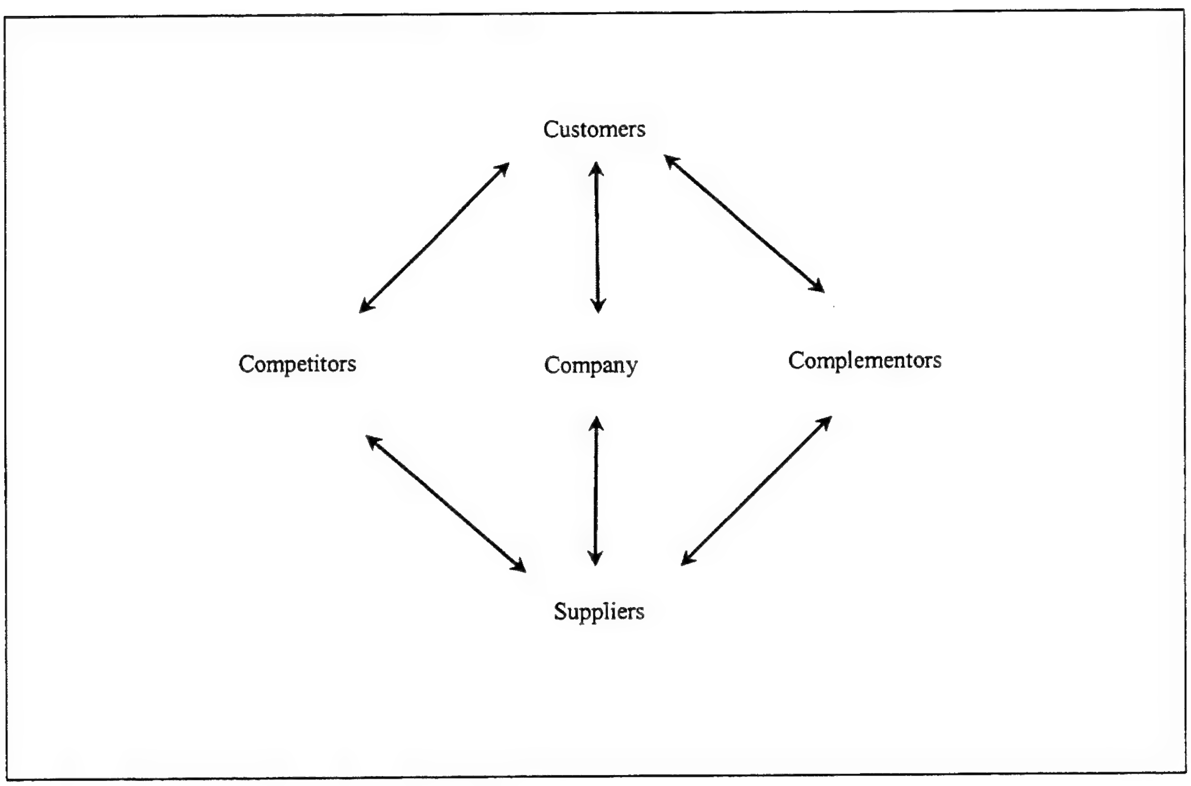


Figure 6 Value Net Axii From [Ref. 8 p. 17]

The quadrants of this tool are Customers, Complementors, Suppliers, and Competitors. Like the Porter Model, the firm or industry being analyzed is at the center of the tool. [Ref. 8 p. 17] The vertical relationships of this quadrant are identical to those of Porter's model. The suppliers are all firms and entities that provide a product or service that is used in developing the company's marketed products. The customers are the buyers of these products. The horizontal relationships are focused on value builders in the relationship. The new entrants and substitutes of Porter's model are included as competitors. "Complementors" is a classification created for this model. The firms and entities at this node are those whose presence in the relationship share cost burdens or increase sales potential. Co-opetition explains complementors using the relationship between computer hardware and software as an example. The more complex the software is, the more powerful the machines must be to operate it and vice versa. Therefore, the advances in one market complement the other. [Ref. 8 p. 14]

Complex relationships between competitors and complementors are created when competitors rely on the same resources. The value-net provides a unique way to map the relationships between competitors and complementors. This adds to Porter's competitive forces model. Where Porter views the industry's environment in terms of forces that must be either confronted or avoided, the value-net views the environment as a web of relationships that must be managed. [Ref. 82 p. 4] The value-net explores the possibility of a proactive firm operating in line with oligopolistic theories. It considers control of relationships as the source of competitive advantage. The amount of control each player has in a relationship depends on the balance of value creation ability, or power, it brings to the table. The net of suppliers, customers, competitors and complementors is used to

subjectively measure the value each member brings to the relationship. The more value a member brings to the relationship, the more power it has over the terms of the relationship.

The value-net uses the quadrants to explain the value/power relationship. This thesis uses the process Brandenburger and Nalebuff explained in their example analysis of Nintendo's actions and strategy. The process requires a systematic review of the **players**, Added Value, **Rules**, **Tactics**, and **Scope** of the relationship model. Each player is identified and placed in its respective quadrant. [Ref. 8 p.115]

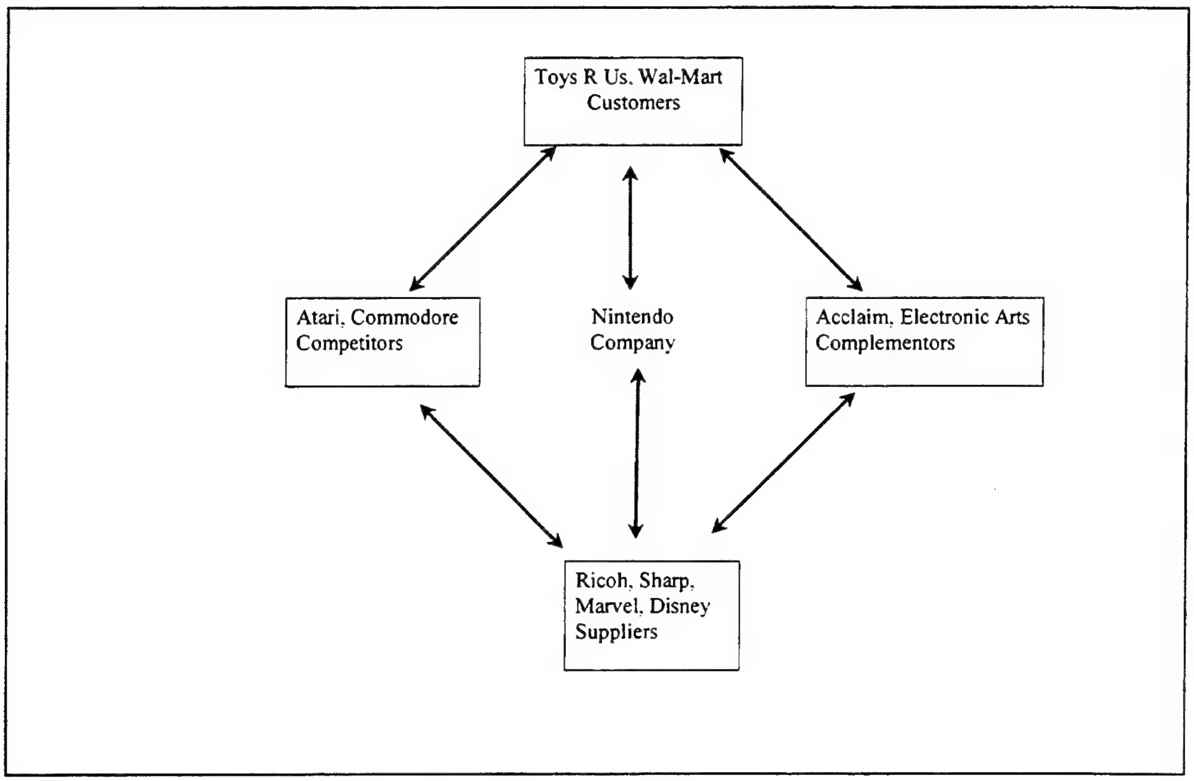


Figure 9 Nintendo Example From [Ref. 8 p. 115]

A general review of the players identifies their objectives for the relationship and the amount of value creation they bring to the table. In the example relationship, Nintendo had to compete with the buying power of the mega distribution systems of Wal-

Mart and Toys "R" Us. If Nintendo produced enough cartridges to meet all the distributors needs, its production value would be less than the stores' distribution value. Nintendo, without a direct sales program, would become dependent on the toy stores. Nintendo had two options, create a distribution system and compete with the stores, or build the value of their production. With only one toy line, Nintendo did not have the economies of scale to compete with distribution networks with the multiple toy lines sold by the stores. It did have a means, however, to increase their value and diffuse the toy store's buying power. By restricting the number of units produced, the orders for all the stores would not be met. The stores therefore had to increase their added value (purchase price) to the relationship or be one of the distributors without Nintendo cartridges. [Ref. 8 p. 115] This research studies the buyer seller environment and the strategies that DoD and the prime contractors are employing to gain a comparative advantage in the value game.

The **rules** of the Value-Net determine how the entities relate; they are the contracts and regulations of the relationships. Nintendo used a security chip in its hardware that required software writers to obtain an access license. This **rule** allowed Nintendo to control what games were produced and how many. [Ref. 8 p. 112] Co-opetition provides examples of other **rules** such as Most Favored Customer (MFC) and Meet the Competition Clauses (MCC). How these **rules** are defined either promote or reduce value for the members of the Value-Net. For example, game theory shows a negative side to a MFC status if the seller as the greater power in the relationship. Under an MFC agreement, a seller promises one buyer the best price and then creates an incentive to ensure all the prices are in his/her favor. [Ref. 8 p. 162] In essence, the **rules**

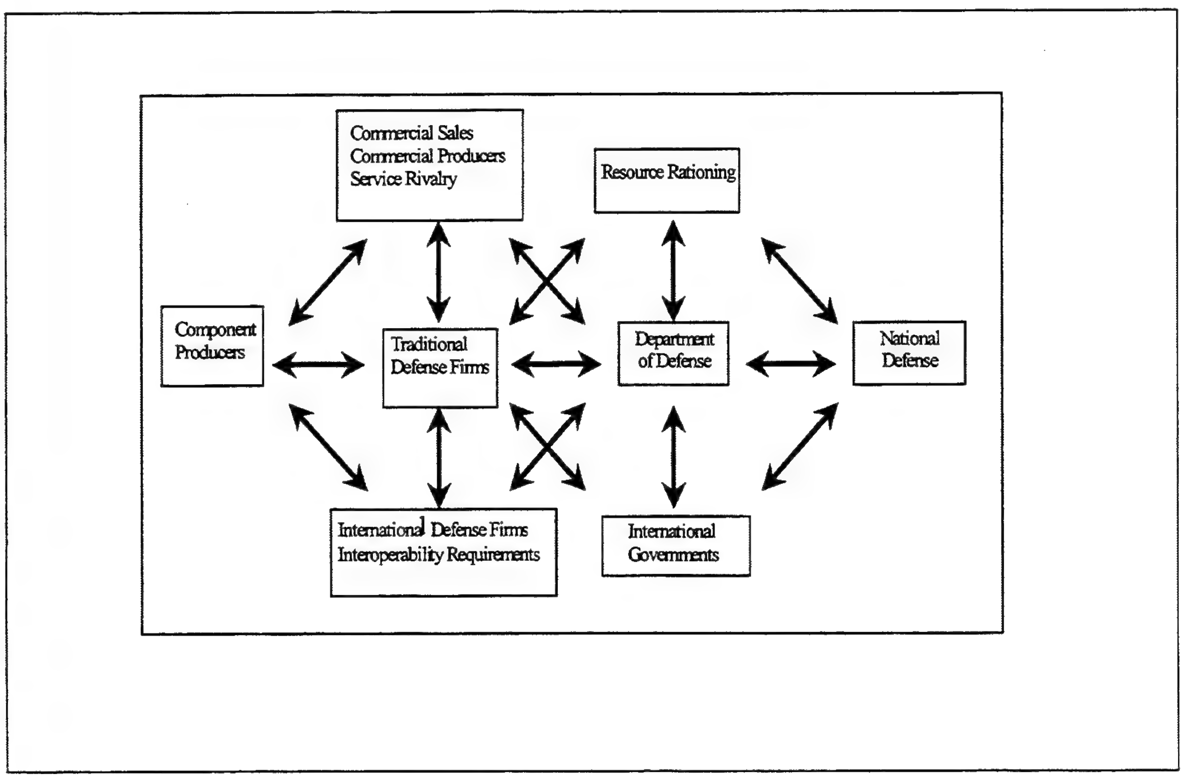
of the Value-Net, or the contracts of the business relationship will reveal positive or negative incentives for value sharing. In this study, DoD is the main **rule** maker. This study identifies the interoperability requirements and the 5000.2 directive, dual use and open architecture initiatives and performance specifications as the three primary **rules** affecting the business relationships.

Tactics are how entities in the Value-Net create and use perceptions to affect the power/value relationship. Nintendo priced the hardware for their video games at a price well below their competitors. This pricing **tactic** served two purposes. First, it established a demand for their high-resolution games. The consumer demand for the games enabled Nintendo's leveraging maneuver that increased their value with respect to the toy stores. Second, it projected Nintendo's resolve and ability to capture the home video game market. [Ref. 8 p. 112] The Value-Net does not identify how or the extent to which **tactics** are used; it identifies their presence in the relationship and between the key players. This study establishes potential areas where competitive **tactics** may affect future competition. Additionally, it identifies the **tactics** that prime contractors use in response to the DoD's **rules**.

The **scope** of the Value-Net is expressed in terms of the length of a relationship and the number of relationships that are linked. A firm benefits from a relationship by managing how linkages and time influence its power/value ratio. Nintendo used time as a value builder when it decided not to allow their eight bit games compatibility with its 16 bit machines. Nintendo ended its relationship with 8 bit producers to ensure a recreation of the value cycle with the 16 bit machines. [Ref. 8 p. 239] DoD's recent initiatives affecting the **scope** of their relationships are its competition policy, investment in science

and technology, and desire for an 18-month life cycle for electronic systems. The industry has increased its subcontracting and teaming arrangements as an effort to manage the **scope** of their involvement.

As is evident by the Nintendo example and other excerpts from Co-opetition, the Value-Net is a versatile tool that allows concise plotting of relationships. While it does not produce a detailed measurement of competitive value. It does provide a comparative analysis of the value/power relationship. This study uses this tool to highlight the predominant **players**, **rules**, **tactics**, and relationship **scope** for each of the nodes in a prime contractor DoD value-net. To apply the value-net model to the Government and its purchases requires a link between the company's market and the Government's responsibilities.



Figures 10 DoD Value Net Developed by Researcher

Although Brandenburg and Nalebuff caution that drawing linked diagrams would quickly get too complex to understand, a relatively simple level analysis of government acquisitions should not pose a problem. For this model development, the Value-Net model is rotated ninety degrees and overlapped at the purchaser node, which is the Department of Defense. DOD's competitors may also be complementors. If the product or service is a commercial item, production capacities may limit its availability creating a competition against commercial users. This aspect is evident if you look at the recruiting and labor force relationship or DoD's competition with the telecommunications industry for circuits. At the same time, the **scope** of commercial sales may reduce costs either through competition among sources or economies of scale. This aspect is becoming of greater relevance as the traditional "Defense Firms" continue to divest and spread their performance over both commercial and defense programs. As a firm's percentage of Defense business shrinks in comparison to commercial business, the firm will gain more value from their commercial relationships. This increases the power of the competitors and complementors in DOD's Value-Net. Notice the crossed influences in the center of the diagram. The cross with competitors is where the traditional Defense view of market research takes place. DOD searches for competitors who will add value to the relationship for itself and diminish the prime contractors power as a sole source entity. The complementor link is less clear. To explain this, Brandenburger and Nalebuff discuss the complementor relationships concerning the F-22. If DOD were to cut back on purchases for avionics on other programs supported by the F-22 contractor, the reduced production scale will increase those component costs in the F-22 program. [Ref. 8 p. 20]

Although the value-net does not provide a detailed measurement of each party's added value, it does provide qualitative principles that may yield a successful strategy. It is an extension of the Porter Model in that it allows a more concise depiction of the competitive forces. It merges the five-force concept with game theory. Game theory's involvement gives the analyst room to consider competition as well as cooperation. It therefore captures the essence of Porter's competitors and the Stakeholders cooperators. By capturing the relationship in terms of players, added value, **rules**, **tactics**, and **scope**, this study analyzes the balance of value and power relationships in the industry for network centric warfare.

2. Value-Net Application

The Department of Defense (DoD) and the industry or prime integrators are the two primary nodes of the value-net. DoD is such a complex entity that selecting a unitary actor that develops a grand plan for achieving national defense is very difficult. There are, however three initiatives since the early 1990's that this thesis uses to define DoD's **rules** and **tactics**. It looks at the value and power created by the emphasis on interoperable systems, the use of performance specifications, and the drive for dual use and open architecture in technology development. The researcher considers the budget reductions since the early 1990's as an element of the environment. The reductions certainly affect the relationships between DoD and the industry, but DoD does not have direct control over them. The budget cuts, therefore, are not considered a **tactic** or **rule** imposed by DoD. For the purpose of this study, the researcher will focus on the global arms market as a complementor and the commercial technology market at a competitor to DoD.

The industry is defined as the prime integrators for the OPSITs defined above. This is not the standard view of the defense industry. It assumes a marked difference between the core responsibilities of the prime contractors and the first and second tier subcontractors. The majority of the prime contractors' efforts are focused on integration of systems, which are produced by the subcontractors. The subcontractors are focused on developing superior technology and quality at the component or subsystem level. The large contractors have specialized as system integrators and are maintaining a reduced production capability. This study classifies the value added performance of the primes as integration and design. The subcontractors develop the components, which are increasingly commercial in nature. The concentration of the industry is defined using the percentage of the primes' value added performance for each OPSIT and then for the total network centric defense system. The four firms with the highest percentage of value added to the network centric defense are the competitors at the company node shown above. The researcher derives the concentration figures from data provided by the program integrators at Defense Contract Management Centers (DCMC) performing administrative functions for the programs listed above. The program integrators were asked the following questions:

1. Who is the prime contractor for the program in question?
2. What is the total dollar value of active contracts?
3. What is the percentage of performance (in terms of contract value) that the prime contractor performs in lieu of subcontracting or purchase?
4. What is the nature of the primes performance? (I.E. Integration and design or component development of a sensor, communicator, or shooter/platform.)

The work performed by the prime contractors is categorized as the development of sensor, communications, or weapons components or as integration and design services.

This research focuses on the percent of available contract dollars received for the integration services. The percentage of available contract dollars received for component development across systems provides an insight into vertical integration attempts at the platform level. Much detailed data on subcontracts and component systems, however, is proprietary, making an in depth analysis beyond the scope of this thesis. Additionally, the classifications of performance are too broad to provide a reasonable measurement of industry concentration for major components. [Ref. 91 p. 73]

3. Economic Principles

F.M. Scherer referred to economic theory as knowledge required to "forge rigorous predictive links between fundamental assumptions and their behavioral consequences." [Ref. 91 p. 2] The value-net identifies key elements of the DoD-to-prime-contractor relationship which form the researchers assumptions of industry structure. Through the application of economic theory, this thesis predicts the likely strategies the contractors are using to establish their competitive advantage. Strategies are behavioral consequences. The research focuses on areas where the economics of network centric warfare production requires a different structure than the industry has created for platform centric warfare production. Once the differences are identified, it determines if and how contractors are making the shift to the new industry structure.

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III. DATA PRESENTATION: EXTERNAL FORCES

A. INTRODUCTION

There are five players involved in the value-net. The Government, the traditional defense contractors, commercial technology firms, international governments, and international defense firms. The DoD and the traditional defense contractors are the primary players. The **rules** established by DoD dictate the nature of involvement for the remaining three players. How DoD shapes its relationship with the traditional defense firms dictates the positioning of the international and commercial players along the vertical plane of the value-net. This chapter reports the **players**, **rules**, **tactics** and **scope** of involvement between DoD and the traditional defense firms and the value building characteristics of the international and commercial **players**. It is broken down into sections listing each node of the value net. Each section contains an itemization of chronological events, policy statements, or as in the case of the industry distribution data that indicate significant signals for the defense industry. At the end of each section, there is a recap of the significant **players**, **rules**, **tactics**, and changes of **scope** affecting industry strategy.

B. THE ENVIRONMENT

The first step in filling out the Value Net is establishing the environment within which DoD and the traditional defense frims relate. The two key elements of the environment are money and technology. Building a military requires money, which is

dependent upon the support of the American people. Maintenance of the existin military requires either more funds or a reorganization that reduces the demand for funds. Future funding will not be substantially above the existing level, eliminating the opportunity to proceed into the future unchanged. [Ref. 98 p. 10] U.S. military spending has never witnessed a sustained peacetime increase. Additionally, the growth of entitlement outlays since the early 1970's now accounts for more than half of the Government budget. DoD is now competing with the rest of the Government departments for a smaller fraction of available funds. The following two charts show the relatively constant level of defense spending compared to the growth of mandatory spending sinde 1962 and how the percentage of total outlays consumed by mandatory and defense spending.

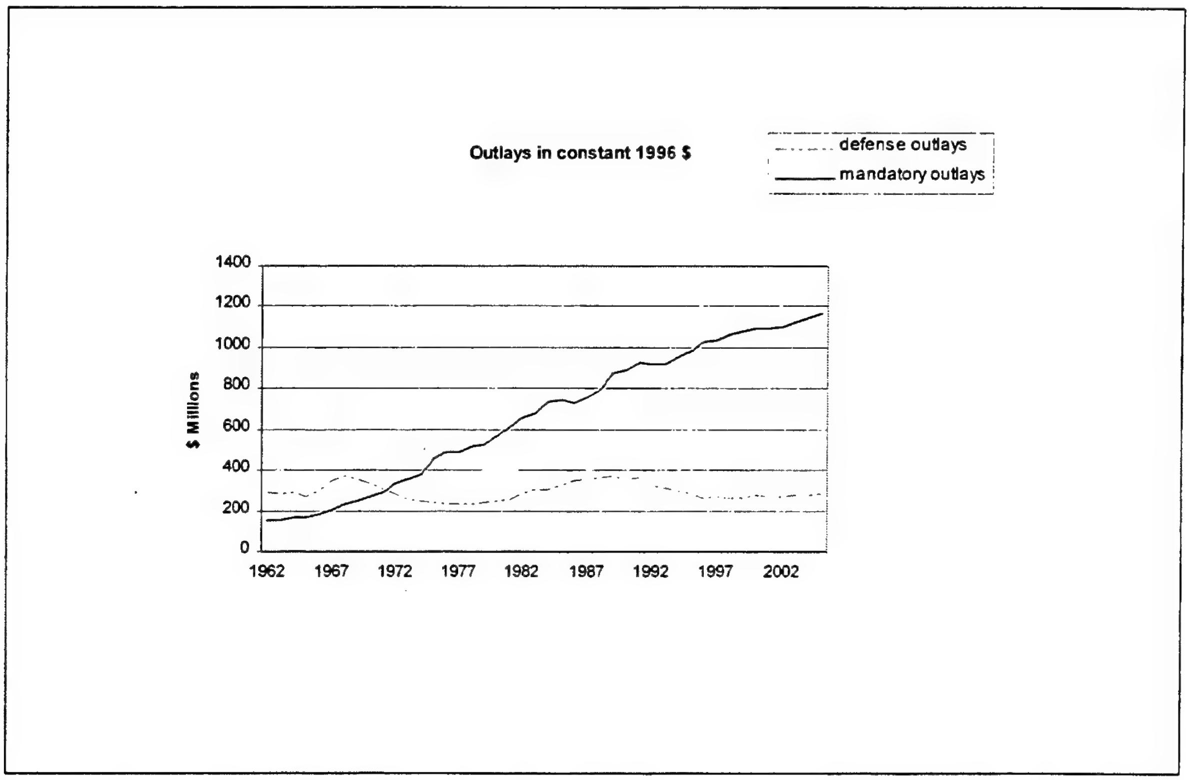

Figure 11 Historical Outlays After [Ref. 106]

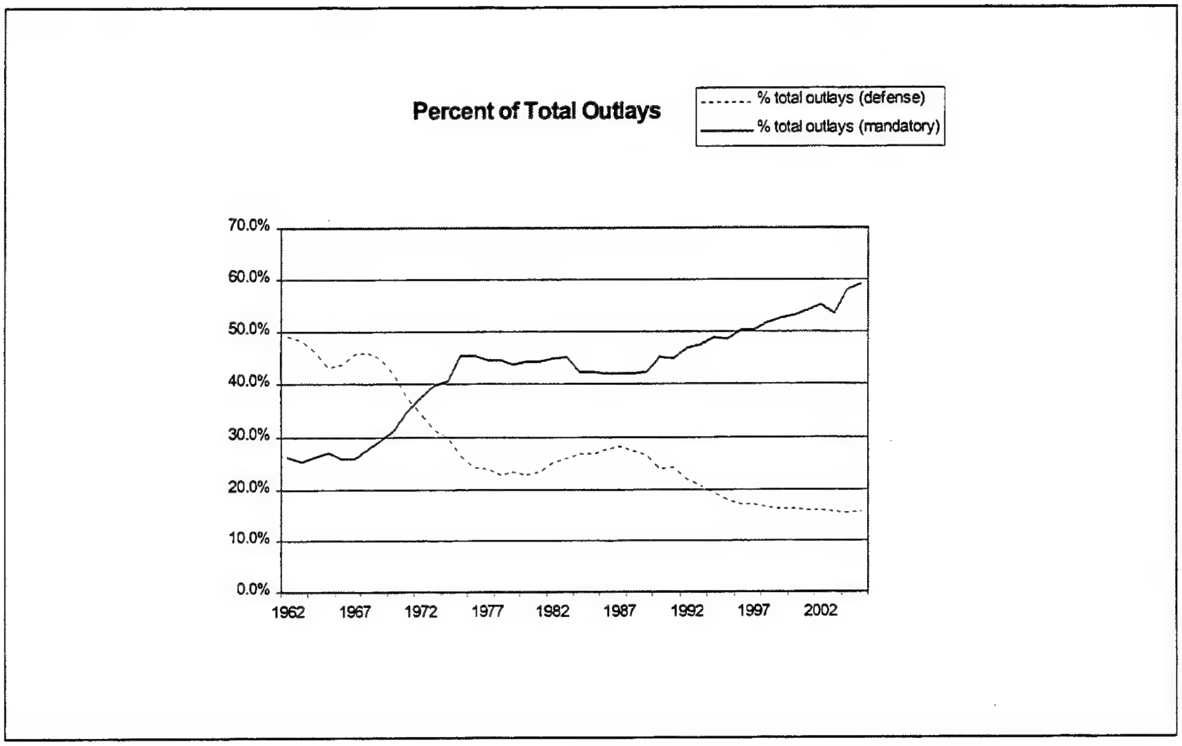

Figure 12 Percent of Total Outlays After [Ref. 106]

Additionally, the cold war inventory was declared to be well above the required structure for post cold war activities. The Bottom Up review of 1993 signaled that the platform development industry did not have growth potential. The review established that maintaining existing levels of military force structure would come at the expense of investment Therefore, increased mobility requirements would be met by already developed systems; modernization would be incremental, generally as upgrades to the existing systems.[Ref. 63 p. 79]

The definition of technology for this analysis is the full spectrum of advancement. It is technical knowledge, development processes, and the resultant applications of research. Under this broad definition, there has been a long-standing bond of

commonality between commercial and defense advancements. Pre World War II technology was intrinsically dual applicable, with trucks, airplanes, and ships relying on the same technical developments. Post World War II, however, there has been a marked divergence of the applications of commercial and defense systems. The missiles, aircraft, ships and tanks, of today appear to have much less technical relevance for commercial applications. [Ref. 3 p. 37] From World War II, through the 1970's, Defense technology and processes spun off to commercial development. Foundational engineering and design tools such as finite-element method (FEM) programs, computational fluid dynamics (CFD), closed loop control systems, and numerical control machine tools, started under defense funded programs. [Ref. 3 p. 41]

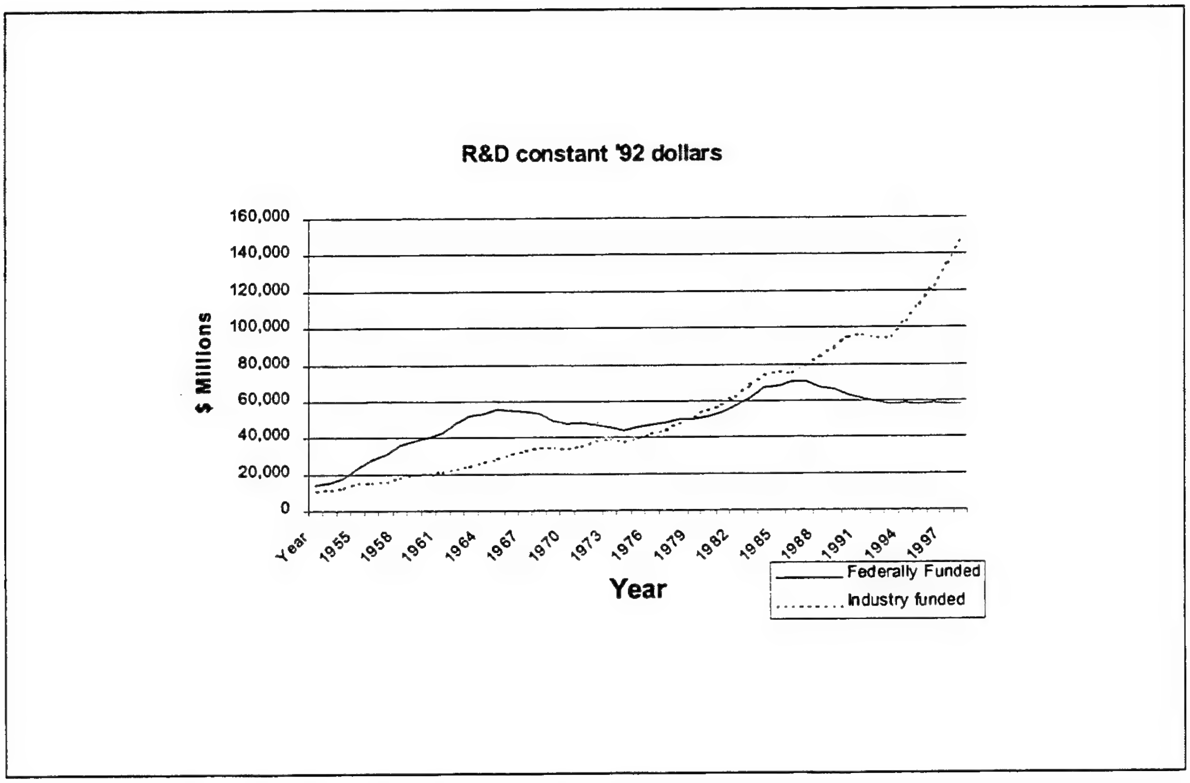

Figure 123 R&D Spending Comparison After [Ref. 68]

The Government's position in the 1970's as the technology leader was justifiably based on the Government making a much larger investment in R&D programs. The recent history of R&D investment, however, shows an explosion of commercial funding versus DoD investment. Leading edge technical knowledge now resides generally with the commercial sector, which is investing almost three times as much as DoD. The unprecedented growth of the technology markets has also led to DoD's dependence on the advancements of commercial applications of technology. In 1975, DoD's share of the worldwide semiconductor market was 17 percent; in 1995 it was just 1.3 percent. [Ref. 63] DoD's purchasing decisions influenced the economies of scale of industry production in the past, but DoD is now subject to the power of much larger customers. The traditional view of technological spin off from defense developments has inverted. DoD is now seeking to *spin on* technologies and shape its products to capture the economies of scale.

C. DEPARTMENT OF DEFENSE INFLUENCES

1. Vision Statements Signal the Requirement

The definition of the **players** in the value-net must start with DoD. DoD is a unique player. As part of the sovereign Government, it has a large amount of control over the remaining **players**. Who in the DoD and the Government is the player in the value-net? There are a myriad of actors with specific concerns and a certain amount of influence over the relationship between the firm and DoD. Congress appropriates the funds, the President develops the budget, the Joint Chiefs of Staff approve the requirement documents, the Secretary of Defense approves the acquisition strategy, the

Services and the systems commands manage the acquisitions; the Federal Trade Commission and Department of Justice regulate corporate activities. These functions of the Government have different ranges of influences. The Congressional and Presidential budget decisions are relatively short term with only two years of reliable numbers and five years of estimates. The Federal Trade Commission and Department of Justice decisions establish limits of corporate activity and have stable goals motivating their enforcement. The two most powerful influences on the DoD industry relationship emanate from the Joint Chiefs of Staff and the Office of the Secretary of Defense. Both offices have a shape the long-range goals and concepts for National Defense through the Defense Planning Guidance and the Chairman's Assessment. The Secretary of Defense, additionally, has influence over the scope of the industry through his procurement approval process, antitrust inputs into the FTC, and approval of privatization initiatives. [Ref. 63 p. 6]

The historical view of DoD's acquisition power points to the Services and their program executive offices as the wielders of DoD influence on the defense industry. When asked to decipher what influences strategic planning by key members of the defense, the Honorable H. Lee Buchanan III replied that the industry's need for profit causes them to focus closely on the organization that holds the money. Since the three Services control the programming of funds, not the Joint Chiefs, this suggests that they are the requirements generators. Admiral Owens alludes to this when discussing the impediments to a true revolution of military affairs. "Specialization reflects the long and inbred preference within the U.S. military to support one's own Service above the others. It takes advantage of inherent efficiencies in the integrated traditions, doctrines,

discipline, and procedures of a single Service and not a joint force. [Ref. 80 p. 227] Admiral Owens concedes this, but he also agrees that since General Colin Powell held the CJCS post, the Joint Chiefs have had a growing influence over the way programs are planned and budgeted. Admiral Owens' own installment of the Joint Warfare Capabilities Assessment Matrix had a pivotal effect on the program evaluation process. [Ref. 80 p. 173] The perceived influence of the Joint Chiefs of Staff is critical to its implications as a player in the value-net because the joint vision and studies established in the early 1990's are key forces behind the shift in the industry's core products.

In the 1970's, Soviet theorists believed a technological revolution in military operations was the near at hand. They observed the U.S. Defense organization demonstrate the capabilities and potential attainment of the revolution during Desert Storm. It was during this same period that the Office of the Secretary of Defense, in particular Andrew Marshall, (Director of Net Assessment), was leading concept studies on the Revolution of Military Affairs and networked warfare. [Ref. 41] The Secretary divided the concept studies by specialty and assigned them to service teams for execution. By 1994, the Services produced a series of vision defining documents The Army published its study results in Pamphlet 525-5 Force XXI. The Air Force developed Spacecast 2020 and Air Force 2025. The Navy produced From the Sea, which led to Forward from the Sea and Operational Maneuver From The Sea.

Force XXI describes information technology as having a thousand-fold advancement in the near future with dramatic affects on the way the Army wages war. It points out that the Army will press the advantage created by the speed and completeness of information. Operations "will involve the coexistence of both hierarchical and

internetted, nonhierarchical processes." [Ref. 99] It additionally defines the potential for cyclic or incremental acquisitions of systems as innovation and rapid technological advancements surpass the Army's warfare capabilities. [Ref. 99] Finally, the doctrine implies that the bulk of the Army's near term efforts in developing Force XXI would be aimed at information technologies. It states "During the first two decades of the twenty-first century, the Army will be at the emerging edge of knowledge-based land warfare." [Ref. 99] It goes on to express that knowledge management technology for the next century already exists, without discussing the propulsion and material technologies required for the faster more lethal force. The implied inference is that systems would be upgraded electronically before being replaced with next-generation faster and lighter units.

Spacecast 2020, highlights the same critical attributes for the acquisition of a future force. It states that transforming technology advancements in national security capabilities requires a three-pronged effort. First is tracking and spinning on technological advancements made by the commercial sector in the areas of computers, electronics and communications. Second, is a Government commitment to research and development efforts in all areas of national security. This includes "leading the way " in areas that require a tremendous amount of research funding. [Ref. 94] The theory of global view, reach and power presupposes a massive amount of data to be collected, transmitted, and fused across computer processors. A majority of the technological advancements required for Spacecast 2020 already reside in the rapidly advancing commercial sector. [Ref. 94]

Air Force 2025 built on Spacecast 2020 and projected the Air Force thirty years into the future. The analysis uses three dominant characteristics to shape eight conditional worlds of the future. It then selects the four most challenging worlds to derive the requirements for the Air Force in 2025. As in previous documents, it does not propose building power on individual systems. The document suggests leveraging information in a global information grid, and using microelectronics to apply precision strikes with many deployable systems. The review of the proposed systems identified the commercial sector as the base for technology, computers, electronics, communications, and for future defense funding. The paper on the World Wide Information Control System (WICS) concisely portrays attainment of Air Force 2025. "There is a high probability a system like WICS could be functioning in 30 years. The commercial sector is currently driving the market for advances in computing and communications technology because of the public's growing appetite for information access and mobile portable communications. Potential military applications cannot be ignored." [Ref. 63 p. 6]

"Forward from the Sea" is the only conceptual document of the Services that does not signal that future military acquisitions will be heavily reliant upon electronic and information management technologies. This document and its predecessor concentrate on shifting the Navy's operations from deep water to the littorals and expeditionary warfare. The Marine successor to Forward from the Sea, Operational Maneuver from the Sea likewise stresses conceptual changes to amphibious assault, especially the importance of achieving the objective without a pause or buildup at the beach. Although it does not stress development of future systems, it does identify intelligence and communication technology as significant enablers. [Ref. 79]

While the Navy announced concepts without addressing technology, it did study the power of information technology. From November 1995 to May 1996, Vice Admiral Cebrowski as director for Command Control Communications and Computer Systems, C4 conducted a study on the Advanced Battle Space Information Systems (ABIS). The results of this study are what have developed into the network centric warfare concept. Again, the key element that shapes the future defense industry product is the need for robust C4 capabilities based on advanced technologies in the information systems and communication sector. "The ABIS of the future depends on advanced information technologies from microelectronics to software." [Ref. 39] An additional stipulation of this report is that the information systems technologies must be upgraded at a much faster pace than the traditional perception of warfare capabilities. "The specific technical or operational advantage that an information product or systems application delivers will erode over time. Continual assimilation and enhancement of new technologies, products, and military applications are necessary to retain information superiority and maintain military dominance."[Ref. 39]

In 1996, Joint Vision 2010 channeled the independent efforts of the services into a joint concept. The vision sees enablers of battle dominance in the areas of logistics, dominant maneuver, precision strike, and full dimension protection. This document and its immediate successor Concept of Future Joint Operations, promote full spectrum dominance through combined forces, but do not explicitly address the traditional divisions of warfare by the services. They do echo the signal that leveraging information technology is the near term method of development for the military. "JV2010 is built on the premise that modern and emerging technologies—particularly information-specific

advances—should make possible a new level of joint operations capability. Underlying a variety of technological innovations is information superiority—the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying and adversary's ability to do the same.[Ref. 14 p. I]

The report on the Quadrennial Defense Review and the discussion around it started the translating the services' and the joint visions into defense acquisition policy. Although the report was controversial because of its political tones and the inclusion of the budget environment in its decision-making, the message to industry about the role of technology in the future DoD systems was clear cut. While addressing the Brookings Institution, Secretary Cohen stated that the platforms of the present will suffice in the near future, but a modernization is needed for the force after next. He went on to address how the modernization would come about:

> This future force will embody the concepts set forth by General Shalikashvili in "Joint Vision 2010." It will seek the best people our nation can offer, equipped with the best technology our imagination can offer. And by harnessing the information technology revolution, we will transform the way our forces fight. We want them to be able to dominate any situation we send them into. We don't want a fair fight -- we want a decisive advantage. This means continuing to build an integrated "system of systems" to give them comprehensive battlespace awareness and cut through the fog of war. This system of systems will integrate the laptop, the microchip, the microwave, the videocam, the satellite and the sensor. It will connect the cockpit, the quarterdeck, the control panel and the command post, and it will link the commander to the frontlines and the supply lines.[Ref. 17]

Secretary Cohen then went on to address the limited budget and the $265 billion dollar question. He explained that the transformation to the future force will require a general sustainment of the existing forces, while investing in the future force with a plan that introduces new systems at the "right pace".[Ref. 17]

In 1998, the Navy addressed the technological considerations and revolution of military affairs issues with the presentation of Network Centric Warfare (NCW). While

the sister Services' and joint vision documents address the commercial advancements to be spun on to defense operations in general terms, the network centric warfare concept narrows the scope of the technology definition. It starts with a study of commercial technologies in use today and identifies architectural and capability sets that have defense applicability. In promoting the NCW concept Vice Admiral Cebrowski gives an example of how NCW capabilities vastly improve the kill ratio of the High-speed Anti-Radiation Missile (HARM) [Ref. 12] The signal once again is that existing platforms will be modernized through the infusion of advanced information technologies.

The Services are using these visions as building blocks for the development of future DoD systems. In his testimony to the subcommittee on airland forces, Lieutenant General Kern, Military Deputy to the Assistant Secretary of the Army for Research Development and Acquisition, states that the Army is modernizing through the Force XXI process. He additionally states that the Army is following a process of recapitalization. "The Army maintains the usability and effectiveness of present systems rather than investing in entirely new systems. The Army achieves recapitilization through extended life service programs, preplanned product improvements, depot rebuild, limited replacement, or technology insertion." [Ref. 53]

The Navy has applied the concept of value added through information and command and control technology to their new development systems. The General Accounting Office report on the Navy's plans to acquire the F/A-18E/F with a multiyear procurement the GAO considered the engine underpowered. The Navy's response was that technological advancements linking the pilot to the missile would compensate for the reduced power. "The Navy does not currently plan to develop a new engine for the F/A-

18E/F to correct these deficiencies because it believes that future upgrades to the aircraft—such as the Joint Helmet Mounted Cueing System and the AIM-9X missile—will provide capabilities that will make the speed and maneuverability of the aircraft less critical in close-in aerial combat."[Ref. 103 p. 5]

As pointed out above, although the joint concept is growing, the Services have been developing integrated systems of systems that are for the most part enclosed in their specialties. Admiral Owens addresses the simulation of jointness during his analysis of the Kosovo engagement. The most telling indication of the failure of jointness is Task Force Hawk. The Apache Longbow helicopters did not fit into the Air Force concept of operations, nor did they communicate with the JSTARS, EC-130, or F-16J's as the information network required. [Ref. 80 p. 11]

Whether it was due to an analysis of the lessons learned from Kosovo or not, three documents produced in the last eighteen months have added the most defining product requirement for the defense industry. The DoD Directive 5000.2, Joint Chiefs of Staff Instructions 3170.01A and 6126.01B define a measure of interoperability in all programs. The 5000.2, affects all existing programs and states that they must be able to "provide data, information, materiel, and services to and accept the same from other systems, units, or forces, and to use the data, information, materiel, and services so exchanged to enable them to operate effectively together." [Ref. 75 p. 11] The key factor of this requirement is that the Milestone Decision Authority will base his or her decision of operability on the family of systems within which the program is expected to operate. Additionally the directive establishes an interoperability key performance parameter in accordance with the Joint Chiefs of Staff instructions. CJCSI 3170.01A defines the requirements

generation process. The document defines the Joint Requirement as a requirement that impacts more than one DoD component, and then states that all command control communications computers intelligence sensor and reconnaissance (C4ISR) programs are inherently joint because of their interoperability integration needs. [Ref. 15 p. A-2] The document further establishes the approval process for the interoperability key performance factor. In accordance with this instruction, the J6 staff will evaluate and certify that all Operational Requirements Documents (ORD), Capability Requirements Documents (CRD), and Mission Needs Statements (MNS) regardless of acquisition category conform to interoperability requirements for their family of systems, system of systems, or for allied forces if applicable. [Ref. 15 p. B-4]

The CJCSI 6162.01B defines how the program officers are to present the interoperability requirements. It stipulates that in the formulation of the acquisition plan program managers must develop a matrix showing all of the top level Information Exchange Requirements (IER). It must delineate what systems it will transfer information with, why the information is transferred, what information is transferred, and how it will be transferred. The IERs must be plotted for every other system in the program's Family of Systems, Systems of Systems, or if applicable any systems it is expected to operate with external to them. It stipulates that at the original stages, unknowns are acceptable, but all IERs should be known at Milestone II. [Ref 15 p. B-1-4] As an illustration of the complexity of the interoperability requirement, the instruction provides a sample graphic showing the System of Systems for THAAD.

2. The Shift to Performance Specifications

While the Joint Chiefs of Staff were stating a vision based on commercial advancements and technology, Defense Secretary Perry pursued acquisition policies that would gain access to those technologies. He opened the 1994 White Paper on specifications and standards with "To meet future needs, the Department of Defense must increase access to commercial state-of-the-art technology and must facilitate the adoption by its suppliers of business processes characteristics of world class suppliers." [Ref. 81] The White Paper instituted three changes that affect industry's development practices. First, it eliminated the requirement for program officers' use of specifications and standards listed in 5000.2. Second, it eliminated binding power of references below the first tier. If a program referenced a specification, it could only be used as a form, fit or function guidance. This removed all specification requirements below the prime contractor level. The primes were allowed to seek subcontractor development of component systems that only met the form fit or function of its military specified (Mil Spec) predecessors. Finally, it encouraged the use and development of non-governmental standards that are consistent with the trends of commercial practices. [Ref. 81] In the 18 months following the release of Secretary Perry's white paper, the Defense Standards Improvement Council oversaw the screening of every military specification and standard in the DoD index with the intent of canceling, inactivating or replacing it with a performance specification. [Ref. 89] This directional shift from designed specifications to form fit and function requirements dovetailed with the signing and implementation of the Federal Acquisition Streamlining Act (FASA). FASA instituted a broader definition

of commercial items. [Ref. 98 p. 114] The combination of these to policy changes completes the transfer from specialized military components to commercial products. The following example clarifies the process. The Air Force was acquiring a transistor with a Milspec requirement of 2500 pounds. They reviewed the specification and found the performance only required 1600 pounds. Then under a final review determined that commercial spec transistors met the performance requirement. The ultimate savings due to the shift to commercial specifications were greater than $25 per part, but more importantly, the method of procurement changed. [Ref. 98 p. 114] In 1994, there were over forty five thousand specifications and standards of which 75% were military or Federal detail specifications or standards. In 1999, there were twenty eight thousand specification and standards of which 43% were military or Federal detail specifications or standards and 8% were performance.

3. Dual Use Initiatives

As stated above, the history of formal or informal dual use programs extend to before World War II. The focus of this research is on the industrial policy and dual use programs starting with the changes the Clinton administration made to the Technical Reinvestment Program (TRP) before its implementation. The TRP was developed to assist the U.S. industry in capturing a lead in technologies that have potential competitive advantages due to early entrance and dominance. The Clinton era announced its goal as job rejuvenation for the Defense Industry affected by budget cuts. The program designers, however, designed it to capture technologies outside the defense industry's traditional scope. The defense firms saw the initial version of TRP as increasing their competition by

attracting commercial firms into defense development projects. [Ref. 63 p. 106] In the face of these fears, the Administration hoped to incentivize partnerships between defense firms with capital and small commercial businesses with innovative technologies. [Ref. 63 p. 130] The plan designated specific areas of research and required industry take up 50% of the research costs. Due to political problems, and lack of substantial rewards, the program foundered. In the 1997, House Resolution 1119 The National Defense Authorization Act created the Dual Use Science & Technology program. It initially authorized $75 Million for 1998 investments and set obligation goals for DoD applied research funds. The goals start at 5% in 1998 and increase to 15% in 2001. [Ref 48. P. 1] The program is similar to TRP in that it is seeking research partnerships in focused areas and the subject products must have a defined military and commercial application. The touted benefits of the program are leveraging scarce Science and Technology funding, promoting industry-to-industry partnerships as well as industry to defense and university partnerships, creating greater access to advanced technologies, and creating markets through defense development of the technologies.[Ref. 33]

4. Open and Joint Technical Architecture

In November of 1995, the Assistant Secretary for Defense for C3I systems released a directive tasking the services to "reach a consensus of a working set of standards" and "establish a single, unifying DoD technical architecture that will become binding on all future DoD C4I acquisitions". Subsequently a Joint Technical Architecture Working Group was established and in August of 1996, the Under Secretary for Defense for Acquisition Technology and Logistics and the Assistant Secretary for C3I signed out

the first version of the Joint Technical Architecture (JTA). [Ref. 51 p. 4] The JTA aimed to reduce cost, development and fielding times and increase portability, the use of Commercial Off the Shelf (COTS) components, and lessen upgrade and interoperability conflicts. [Ref. 65] The architecture is structured in three layers; core, domain and sub domain level.

The core has a minimum number of mature commercial standards that promote information transfer and commonality between all systems. This core of standards must be met by all DoD systems. There are four domains below the core: Combat Support, C4ISR, Modeling and Simulation, and Weapon Systems. Each of these domains again has the least number of standards possible that are peculiar to its systems. Finally, at the sub domain level there are twelve areas again each with their own characteristic standards that must be met.

In the spirit of acquisition reform, the applied standards must enhance interoperability, be widely accepted in the market place (mature), technically implementable, and be public. [Ref. 51 p. 11] The Office of the Secretary of Defense components, Military Departments, the Office of the Joint Chiefs, Unified and Support Commanders, and the Intelligence Community form up the Architecture Coordination Council, which is the final approval authority for the JTA. Their overarching goal is to move the development of systems to an open architecture and promote seamless interoperability between defense systems and organizations by reducing the number of domain and subdomain architecture requirements. The Defense Science Board's Open Systems Task Force described the goal of open systems as the achievement of plug and fight, plug and play, and COTS insertion capabilities. [Ref 39 P. 6]

Plug and Fight is the ability of whole systems of systems to operate together. A relatively simple example is the seamless coordination of the operators and systems of the Navy's Aegis units and the Army's Patriot units. It means that when Aegis receives a data packet from a Patriot system, the operators will understand the symbology, and the Army's prosecution process, thus preventing a conflict. It ensures the Commander's intent is understood and acted upon by both systems. In essence, Plug and Fight is the ability for both the systems and the operators to communicate and execute on a common language and doctrine.

The Plug and Play level is what we commonly understand, as interoperability at the system level. The components are universally interchangeable and common interfaces allow universal communication between systems. The use of Commercial Off The Shelf (COTS) and plug and play capabilities are complementary in this respect. COTS items create increased plug and play capabilities and the minimal standards of plug and play design goals increase the use of COTS. Additionally, the board viewed open systems architecture as the key to systems viability. Through open system architecture, a platform would be able to upgrade as quickly as the life cycle of its subsystems require.

The Defense Science Board analyzed cycle rates and confirmed that platform structures have stable cycle rates for 30-50 years, basic architectural elements' cycles are stable for 10 – 15 years, and electronic components are stable for 18-36 months. [Ref. 40 p. 45] The task force provided two programs as examples of the trend towards layering of systems and modular designs. The Boeing Oscar TACAIR data processor is an example of how modular design mnimizes and standardizes the interface points for the high cycle components and preserves the architecture and backbone of the system. The Navy

Submarine Combat Control and C3I Systems is an example of developing the system such that the electronic component level is "isolated" from the basic architecture and platform. The isolation makes it easy to plug and play components without changing the architecture of the entire system. [Ref. 40 p. 22]

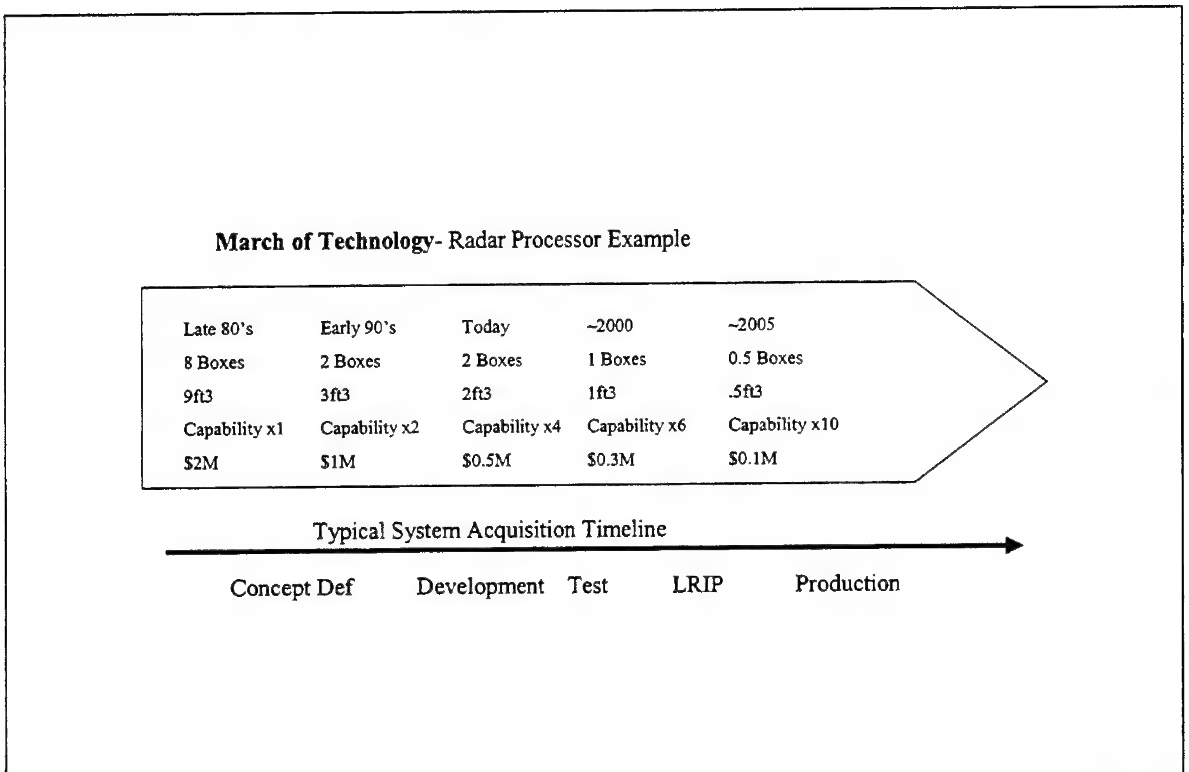

Figure 14 Technology Life Cycles From [Ref. 39]

Additionally, the Combat Control System was developed as a replacement system for the obsolete and unaffordable BSY-2 System. The open system architecture and COTS compliant components created a system 57 times more capable, with 18% of the development costs, 50% of the development time, and 22% of the installation cost. [Ref. 40 p. 22] At the system level, program offices use a rigorous process and an Architectural Control Board (ACB) to move to open systems. One identified difficulty with the move to open systems, however, is the interaction with legacy systems, which often have proprietary architecture and component specifications. [Ref. 40 p. 7]

In 1998, the report stated that the success of some programs does not signal that DoD has in general accepted Open Systems development. The main reason given was that at the time, DoD leadership had not fully supported the concept. [Ref. 40 p. 51] The changes to 5000.2 and rewrites of the Joint Chiefs of Staff instructions indicate that the leadership has increased the emphasis for open systems development and plug and play capabilities.

In a conversation with Mr. Ted Stanford, Deputy Program Manger for the Cooperative Engagement Capability (CEC), he said; "communicating is easy." [Ref. 95] In further discussion, it became clear that he felt the actual transfer of information from one unit to another (plug and play) is becoming easier. What is more difficult, however, is getting the systems to act on the information to an adequate level of performance (plug and fight). He provided an example of the different ways the Automatic Carrier Landing System (ACLS) and an Aegis destroyer react to a signal of an aircraft approaching with a descending flight path and not transmitting an Identification Friendly or Foe (IFF) signal. The carrier will receive the data as a landing aircraft and accept it into its system, while the Aegis system will hold it as an incoming hostile and target it. CEC can easily pick up the information packet from the carrier and transmit it to any other unit in the battlegroup. An Aegis unit, however, will clearly understand the information, but because of the imbedded combat doctrine in the software will process the information in a way not intended or desireable. These conflicts at the plug and fight level are the source of potential prime contractor involvement as DoD strives for the total force interoperability required by network centric warfare.

5. Department of Defense Summary

The key **players** in DoD are the Joint Chiefs of Staff and the Secretary of Defense. Although the Service components have the access funds and interface directly with the industry on individual programs, the Joint Chiefs have exercised considerable influence in shaping the long-term vision for DoD requirements. As the decisions and actions of the program offices experience increased guidance from the OSD and JCS staffs, the industry will witness strong signals that have a greater impact through long-term survivability than short-term profit gain.

The important **rules** are technology capture and an interoperable system of systems. DoD sees value in a firm that will bring innovative, but tested, technology to existing systems fast. Additionally, DoD is constantly looking for the next innovation to give weapons systems the dominant edge. The interoperability **rule** is a complication because innovative technology must work seamlessly with all the other stages of technology in the system of systems. Defense industry must consider cost, competition and resource implications of these two **rules** with every project they undertake.

The use of performance specifications, dual use technology initiatives and open systems architecture requirements are **tactics** within the Value Net model. DoD is trying to tap the wealth of commercial technology directly. It is implementing policy that will increase pressure for innovation. The industry must break down proprietary information wall that it successfully built over the 1970's and 80's or its system components will not meet the interoperability requirement. While the industry is making itself vulnerable to

new entrants, DoD is seeking out potential competitors with larger economies of scale in the commercial market.

The scope of the relationship has undergone a transformation to match the levels of the JTA. The major systems are now just the top end of the scope equation. This top end is reduced considerably. Platform structures are expected to last 30 years or more, and production numbers are expected to match the reduced size of the military and increased leverage created by technology at the lower levels of the architecture.

The middle architecture is the last refuge of proprietary knowledge. The architecture sockets must be open to allow the new and short life cycle components, but the process must marry with specifically tailored service or operational doctrine. At this intersection of code and doctrine, systems integrators have proprietary insights. The lowest level component systems are treated as a technology commodity open to free competition with any innovator that can improve upon universal structures and public architecture.

D. INTERNATIONAL INFLUENCES

Defense spending in the three global regions matched political environments. Spending in the European theater declined with the end of the cold war. NATO reductions have stopped, with some increases in spending visible. The Pacific Allies of Japan and Korea have not reduced spending, but showed a slowed increase due to their economic situation in the early to mid 1990's. The increase in spending in 1998 is an indication of how improved economic conditions have allowed them to focus on their national security concerns. The Gulf Cooperation Council shows a continuous increase in spending due to the tensions in the area, after correcting for the effect of the Gulf War.

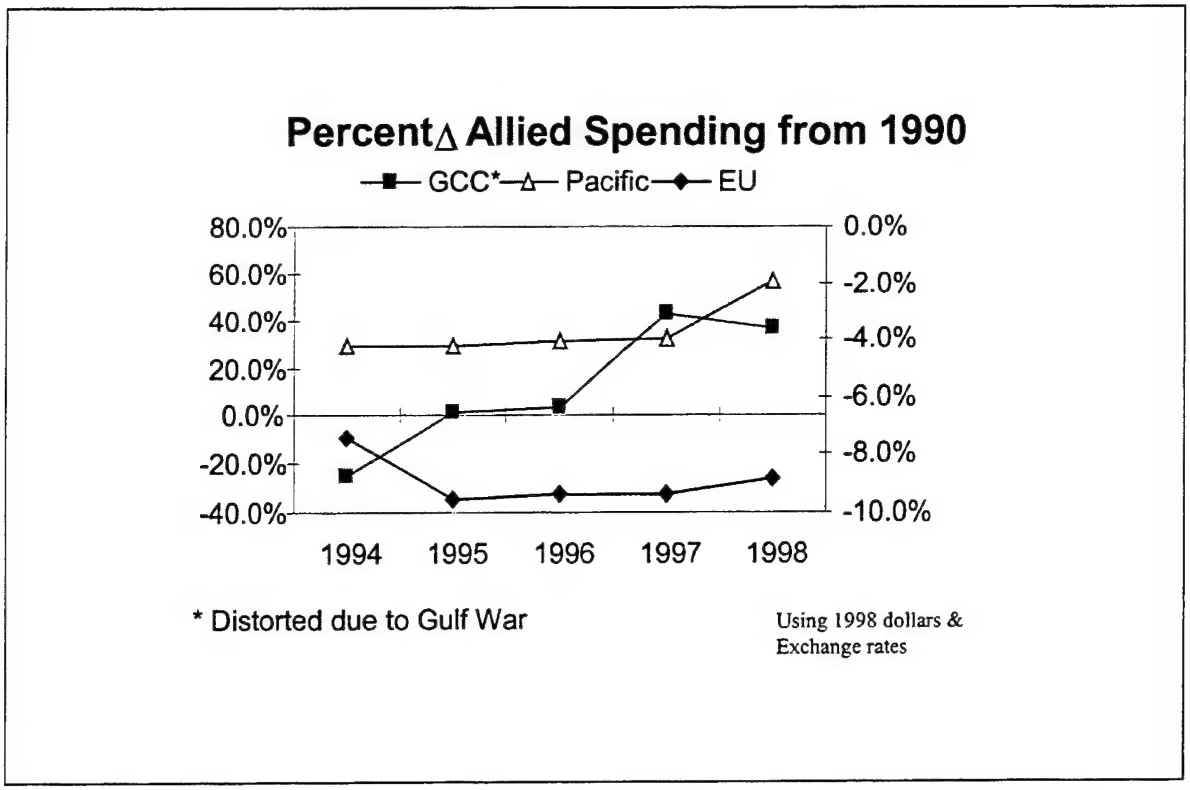

Figure 15 International Defense Spending After [Ref. 88]

The lessons learned from the Kosovo air war, identified a dramatic difference in capabilities between U.S. and Allied forces. [Ref. 80 p. 190] In a speech to NATO on June 19, 1999, the Honorable Jacques Gansler emphasized that the future of warfare will require increased coalition involvement, and must be swift and decisive, meaning execution in days and even hours, much faster than NATO has traditionally acted. He went on to state that the U.S. is using information technology to leverage its military capabilities and the success of coalition operations requires that NATO and other allied forces be prepared to do the same. [Ref. 43] Since the U.S. has 46% of the allied tactical aircraft inventory, 44% of the ground capability, and 58% of the naval force tonnage, it seems reasonable to assume the U.S. will drive the NATO interoperability standard.

Global industry structure has a strong influence on the structure of the domestic industrial base. Either with offsets in the foreign military sales process or the attractiveness of foreign production, the number of co-production and co-development projects has risen. Co-production is the international sharing of manufacturing. Co-development is the international sharing of design responsibilities. Since 1980, there has been approximately a 50% increase in Trans-Atlantic Co-production programs/Co-development programs every five years. [Ref. 63 p. 312] There has also been a comparable increase in Co-development/Co-production programs in the developing world. [Ref. 63 p. 313] Recent history, however, has witnessed a dramatic change in the Co-development and joint venture projects between the U.S. and the European theater. Between 1976 and 1990, the number of intra-European and transatlantic joint venture programs has been about equal. Since 1990, however, the number of intra European joint ventures has outnumbered the transatlantic ventures by more than a 2 to 1 margin. [Ref. 63 p. 322] The recent merger activity in European defense firms has reinforced the separating trend and produced European defense companies comparable in size to the biggest U.S. firms. In 1996, the United Kingdom acquired over six billion dollars of new defense procurement with UK firms. This uncharacteristically high use of British firms over U.S. suppliers is yet another signal that the European nations are seeking alternative sources to U.S. industry. [Ref. 62 p. 218]

The key **players** at this Value Net node are the Allied Governments and the European defense industry. The Allied Governments must upgrade their forces to maintain a compatibility with the U.S. system of systems. All of the Allied blocs are increasing defense expenditures, trying to keep pace with the revolution of military

affairs. The presence of a growing international market creates some growth in the middle level or platform segment. If the U.S. defense firms can capture the sales from this growing market, they will bolster their economies of scale and increase domestic competitiveness.

The growth in defense requirements in their countries and elsewhere also creates an opportunity for the revival of the European Defense Industry. The **tactics** employed by the European governments are use of offsets and recent preferences for home built systems. European industries have leveraged their technology and production base to create a become competitor for the U.S. defense industry. At the same time, the European industry is undergoing a consolidation phase to bolster its competitiveness against the U.S. industry. The U.S. defense industry must, therefore exploit the interoperability requirement to reduce the influence of government-supported defense firms from Europe. In essence, the Allied nations must balance between nationalism and the need to be interoperable with 45% of the world's forces created by the U.S industry.

E. COMMERCIAL SALES AND PRODUCERS

The use of performance specifications, dual use investment programs, and open systems architecture policies discussed above target commercial industry. In 1998, budget estimates for savings due to commercial purchase were between $10 billion and $20 billion. [Ref. 63 p. 214] Three General Accounting Office (GAO) reports identify three different levels of acquisition where commercial firms could enter the defense industry. An analysis of satellite control systems identified commercial systems that were better than government developed systems. The report on the Army's Family of Medium

Tactical Vehicles (FMTV) program and their Heavy Equipment Transporter (HET) identified instances where commercial products with minor adjustments (NDI) products met defense requirements. Finally, The Air Force Materiel Command sponsored pilot program for components in the F-22 system, which highlighted how changes in architecture and specifications allow substitution of commercially built components at the subcontractor level.

In May of 1999, GAO reported on DoD's progress in integrating and improving its satellite control capabilities. It looked at the Air Force and Navy's attempts to upgrade their aging satellite control systems. The two satellite control systems were government developed. The Air Force system was developed with proprietary software and very costly to maintain. The Navy system required replacement because the firm that provided the computers eliminated their software maintenance capability.

In 1995, the Air Force decided to acquire an integrated satellite control system. They down selected from four concepts. The options consisted of a system developed by the Government (DCCS), a system of integrated COTS components (COBRA), a pure commercial system (OS/COMET), and the existing shuttle mission control system. The Air Force determined that all of the systems would have to undergo some level of modification to fully meet requirements. It therefore chose to alter the system they were developing, DCCS, even though the other three systems were already operational. The DCCS system encountered design problems and was terminated in 1997. The commercial variants, however, have continued to have successful implementations. O/SComet is used to control the GPS satellites and COBRA controls three research satellites and has shown an ability to control military satellites. The report additionally identified another

commercial integrated satellite, SSC-21, which the Air Force is procuring for the SBIRS program and a pure commercial satellite, Epoch 2000, that appear to meet all the Air Force requirements. [Ref. 105 p. 8]

Army programs emphasized the ability of commercial firms to make minor modifications of existing commercial products to meet the government need. Two of the three programs used a commercial truck model as the baseline for production. The GAO report asserted that the FMTV program used a commercial truck as a baseline as well, but in its description identified it as a modified Austrian Army vehicle designed by Steyr-Daimler-Puch AG the HETS and LET, however, required only minor modifications of vehicles that the contractors produced commercially. Freightliner in fact did not have to modify its vehicle at all to meet the primary and secondary requirements, but added an additional axle to create an off road capability. [Ref. 105]

One pilot example consisted of a research and development contract with TRW's Avionics Systems Division for the redesign of a military-unique product to be produced on a commercial production line. The contractor succeeded in its performance objective. The final product, a component for the F-22 met all longevity requirements except high temperature endurance. The team thought however, that this ability would be resolved with further test and analysis. The conversion expected a savings of 20% due to less expensive materials and 20% from reduced administrative costs. The commercial line produced 15,000 components a day, while the military only run was expected to produce only hundreds of products per day.[Ref. 107 p. 4]

These reports showed a capability for commercial firms to enter the defense industry with cost and technology advantages. The issue at hand, however, is whether

they will. In the Satellite control system case, GAO reported that several private firms offered to demonstrate their satellite control systems. [Ref. 104 p.14] In the other examples, however, Freightliner, Osh Kosh, Stewart Stevenson, and TRW all have military divisions.

In an effort to attract more commercial involvement, DoD awarded 97 Section 845-Other Transaction Agreements (OTA) amounting to $2.1 Billion since 1993. These OTAs allowed a relaxing of Federal Acquisition Regulation (FAR) guidance, often touted as the major barrier to commercial involvement in government acquisitions. A GAO report surveying the 97 transactions found that 60% of the OTAs were designed specifically to attract commercial involvement. Thirty-seven of the transactions were specifically identified as part of the Commercial Operations and Support Savings Initiative. This DoD initiative targets areas were commercial acquisitions have a potential benefit for DoD. Of the 97 transactions 84 were with traditional defense firms and only 22 had non-traditional firms act as subcontractors.

The key **players** at this node are any commercial producer that has systems that may be inserted directly into the defense system of systems. The GAO examples show that commercial companies are viable competitors for future defense systems. The GAO report on OTAs, however, shows that even with relaxed regulations, commercial contractors are not willing to have a prime contractor relationship with DoD.

The **Rules** for this group of **players** are, therefore, that DoD must make it more appealing for these firms to enter direct competition, or expect to use a traditional defense firm to buffer the relationship.

Available **tactics** are:

1. Refuse to do business.
2. Create separate DoD divisions.
3. Use a traditional defense supplier to interface with DoD.

F. SUPPLIERS

The above discussion of dual use initiatives illustrates how DoD is attempting a dramatic shift in the civil/military structure among defense producers. Two perspectives of the prime contractors' supplier base show that at the second and third tier subcontractor level civil military integration exists. The information systems and electronic industries as we have stated above are primarily commercial. As early as 1992, the Air Force realized that electronic components accounted for 40% of aircraft costs, 70% of air-launched missiles and 80% of satellite costs.[Ref. 104 p. 4] A 1991 study of the Machining intensive Durable Goods (MDG) sector have shown a growth of commercial dependence on traditional defense subcontractors. According to the study, the durable goods accounted for 82.5% of DoD's manufactured goods procurement and the MDG sector accounted for more than half of all durable goods purchased. [Ref. 52 p. 525]]

The semiconductor industry exemplifies DoD and the prime contractor's influence as customers in the electronics sectors. Firms with the Standard Identification Code of 3674 produce micro-electric, integrated circuits and semiconductors. The industry sales in 1999 topped $149 Billion or almost 60% of DoD's 1999 Total Obligation Authority (TOA) of $258 Billion. Personal Computers and communication systems encompass over 50% of the end-use market for semiconductors. [Ref. 93] Major companies in the Communications market estimated annual sales for 1999 to be between $380 and $400 Billion. The firms additionally estimate the sales growth rate to range

The production for the semiconductor industry reached over 93 % of capacity in the fourth quarter of 1999. [Ref. 93] The combination of continued explosive growth and the capacity limitations pose problems for DoD and its low margin arrangements.

The MDG sector survey had responses from plant managers in 973 plants in 21 industries. The survey revealed that of the 48.8% that had defense contracts, 80.4% integrated their civil and military production. The report identified an increased dependency on DoD contracts as the firms became larger and an even more significant difference between those that held prime contracts and those that only subcontracted for defense sales. The report summarized its data as follows:

In short, at the level of the plant, we find considerable integration between the commercial and military industrial spheres in the MDG sector. Large multiplant firms that do defense prime contracting tend to be slightly more dependent on DoD contracts than are subcontractors. Overall, we find that defense production in the MDG sector (whether directly for DoD or indirectly through subcontracts) usually takes place in facilities in which the majority of shipments go to commercial customers. [Ref. 52 p. 525] Finally, the report showed that these firms were using innovation, and diversification to add value to their business rather than economies of scale and quality improvements.

The **Players** in this node are the second and third tier subcontractors. These firms are the source of the innovation and improvements at the component level.

The **Rules** these firms are applying are really a reflection of independence from the defense market. As economic conditions continue to be favorable, these firms are finding revenue sources other than the traditional defense customers. The supplier's

growing independence is reducing the value and leverage the defense firms and DoD have in the relationship. These firms' future is in commercial market; they do not see an advantage in working with DoD.

IV. DATA PRESENTATION OF THE INDUSTRY

A. INTRODUCTION

The data for this study come from 78 programs the literature review identifies as the near term hosts for network centric warfare. A search of these programs in the Infobase Publisher's Competitive Intelligence Website (infobasepub.com/main.html) identified 92 prime contractor relationships for the development of these programs. With the approval of the Defense Contract Management Agency, the program integrators and administrative contracting officers, where identifiable for these relationships, were queried about the prime contractors' involvement. The DCMA personnel were asked the following:

1. Who is the prime contractor for the program in question?
2. What is the total dollar value of active contracts?
3. What is the percentage of performance (in terms of contract value) that the prime contractor performs in lieu of subcontracting or purchase?
4. What is the nature of the primes performance (i.e. Integration and design or component development of a sensor, communicator, or shooter/platform.)?

Where prime integrators were not identified or non responsive, the researcher sought the same information from the respective Service program office or the Infobase Publisher's Competitive Intelligence Website. The data collection resulted in identifying the prime contractors and the total dollar value for active contracts for all the programs.

However, it identified the percentage of prime performance for only 61 of the 92 prime contractors producing the 78 programs.

This chapter presents the collected data on three levels: position, total revenue stream, and value added in 1999. Position is prime contractor presence across the three lobes of the network. A plot of presence identifies areas of expertise. The second level focuses on total value of active contracts in each warfare mission. (Active contracts are defined as contracts that the prime contractor is performing in August of 2000, which was the month DCMA approved the survey.) The term "active contract" equates to a wide performance period. Contracts that were awarded in the 1990's could still be open and contracts awarded in 2000 would have up to 5 years of performance period left. This plot shows degree of consolidation (or diversification). It identifies where DoD is expending its resources in each warfare mission and which contractors are capturing those revenues. The third and final level is the value added that a prime contractor provides to a specific program in one fiscal year, 1999. The value added is calculated by multiplying the FY1999 budget for a specific program by the percent of prime performance and then subtracting the estimated prime profit. The profit is the firms' segment margin reported in their 1999 annual reports. The 1999 budgets for each of the programs were taken from the Department of Defense 1999 Procurement and Research and Development Exhibit Books P-1 and R-1. Budget line items were attributed to the program only if it contained a direct reference in the title. Service component budget books were referenced for the 25 programs that were not specifically mentioned in the P-1 or R-1. The budget information from the service components came from line items that either mentioned the program in the title or had a categorical title and listed the program in a tabulated breakdown. Where

available the value added plot adds useful detail to the total performance plot above. It identifies where and to what extent the prime contractors are expending their resources to capture the defense dollar.

B. OPERATIONAL MANEUVER FROM THE SEA

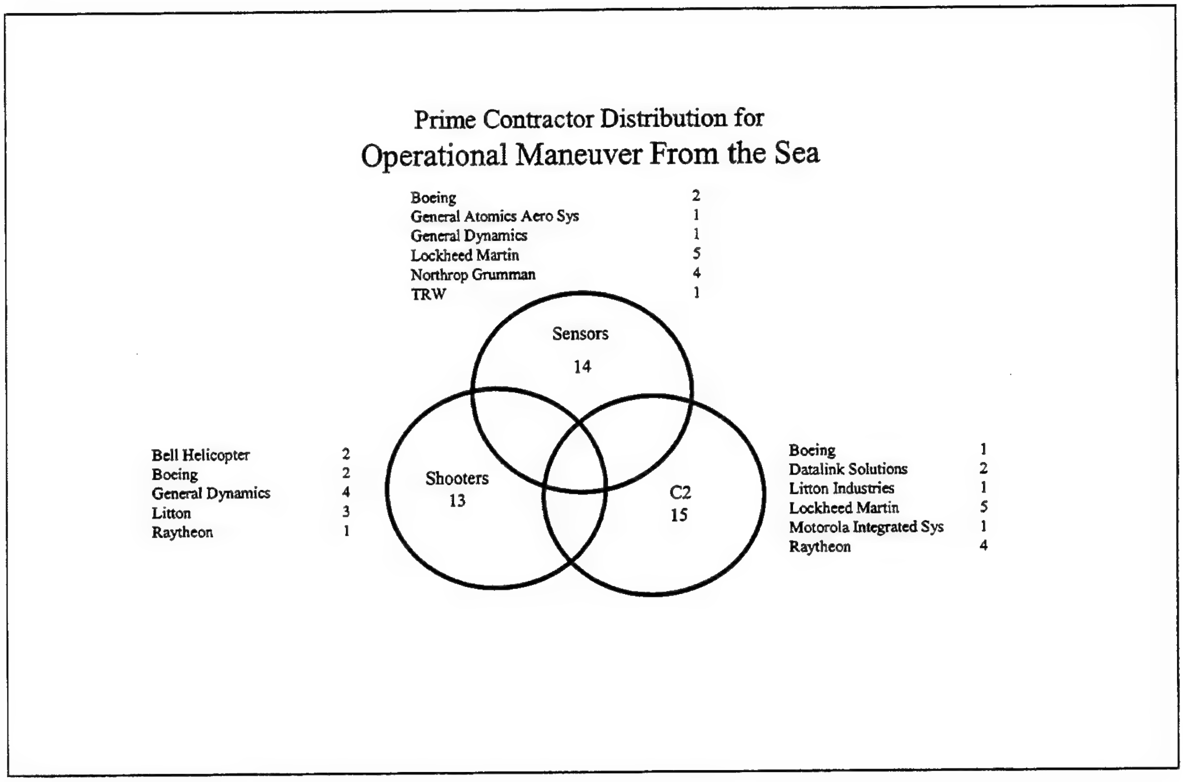

Figure 16 OMFTS Industry Concentration Developed by Researcher

In the OMFTS warfare mission, only five prime contractors show a significant presence defined as having a prime contract for multiple programs in a single lobe, or at least one contract in more than one lobe. The Boeing Company is the only prime contractor that has prime contracts in all three lobes of this warfare mission. Boeing's C2 contract is the NAVSTAR GPS IIF program, obtained through acquiring Rockwell

International Satellite & Space Defense Systems Division (Downey, CA). The sensor programs are a departure from Boeing's more traditional base of aircraft and space systems. These programs are the Zumwalt Class Destroyer DD-21 and the Long Term Mine Reconnaissance System (LMRS). Boeing is partnered with Litton Industries' subsidiary Ingalls Shipbuilding in leading the Gold team in the competition for development and design of DD-21. The LMRS is an autonomous underwater vehicle expected to seek out and report on mines in littoral waters. Boeing's presence in the shooter lobe is as the prime for the V-22 and AH-1W programs, which is part of the traditional role as aircraft producer. Lockheed Martin has multiple programs in both the sensor and C2 lobes. Raytheon is heavily concentrated in the C2 lobe with four programs and has one program, Extended Range Guided Munition (ERGM), in the shooter program. Northrop Grumman has four programs in only the sensor lobe. General Dynamics and Litton have presence in multiple lobes due to acquisition of Bath Iron Works, Electric Boat, and Ingalls Shipbuilding. Note that General Dynamics does have a non-ship program in this warfare mission with the Advanced Amphibious Assault Vehicle (AAAV). The ship programs are plotted on the chart according to their acquisition strategy. The DD-21, DDG-51, NSSN, and LPD-17 programs are plotted in multiple lobes because these programs identify a separate prime for the integration of their warfare systems. The DD-21, DDG-51, and NSSN programs each have both a sensor and shooter prime contractor, while LPD-17 has both a C2 and shooter contractor. The LHD and SSN-21 programs do not have a separate prime for warfare systems integration. They are plotted according to the researcher's judgment regarding their primary function in the OMFTS mission. The LHD is plotted as a C2 unit while SSN is

plotted as a sensor. Motorola is not considered to have a significant presence since it only has one program in a single lobe. Its program, the common ground station, however, is used in every warfare mission and is at the center of the open architecture and interoperability debate.

DoD has active contracts for over $41 Billion attributed to the OMFTS warfare mission. Northrop Grumman holds the highest percentage of active contract value with over $9 Billion. Two thirds of the value is attributed to the JSTARS program. Lockheed Martin, with ten programs in the C2 and Sensor lobes, has just over $8 Billion in active contracts. $5.1 Billion of Lockheed's C2 revenues are due to the Advanced MILSATCOM and MILSTAR satellite constellations. The Advanced MILSATCOM is the planned replacement for the MILSTAR constellation starting in 2006. The acquisition strategy for the Advanced MILSATCOM started as a competition between Lockheed Martin, Hughes Space and Communications (now Boeing), and TRW. In November 1999, however, the three companies and the Air Force decided on a single team effort lead by Lockheed Martin. [Ref. 86] The maintenance of the MILSTAR in conjunction with the development of the replacement Advanced MILSATCOM, therefore, overstates the revenue stream that Lockheed Martin would obtain for the long-term involvement in the C2 function for this and all other warfare missions. The shipbuilders, General Dynamics and Litton Industries follow closely behind with their capital-intensive programs. Although Boeing has presence across the whole warfare mission, its active contracts are only about half the value of Northrop's and Lockheed Martin's.

In 1999, $9 Billion of investment funds were obligated in support of 42 programs. The value added calculations for OMFTS are skewed, primarily due to lack of prime

performance data from ship producers. These omissions underreport the percentage of performance added by General Dynamics, Litton Industries, and to some extend Lockheed Martin and Boeing. The plot below shows how the individual primes contributed to the development of OMFTS mission capability. In essence, thirty five percent of investment in the OMFTS system of systems is attributed to the efforts of Northrop Grumman. Although Boeing has only half of the total active contract value of Lockheed Martin, the company has a comparable percentage of value added performance in 1999. Datalink Solutions is a joint venture created by BAE Systems and Rockwell Collins for the production of the MIDS FDL and MIDS LVT terminals. Although Datalink Solutions is the technical prime, the entity does not add value other than to be a clearinghouse for the partners.

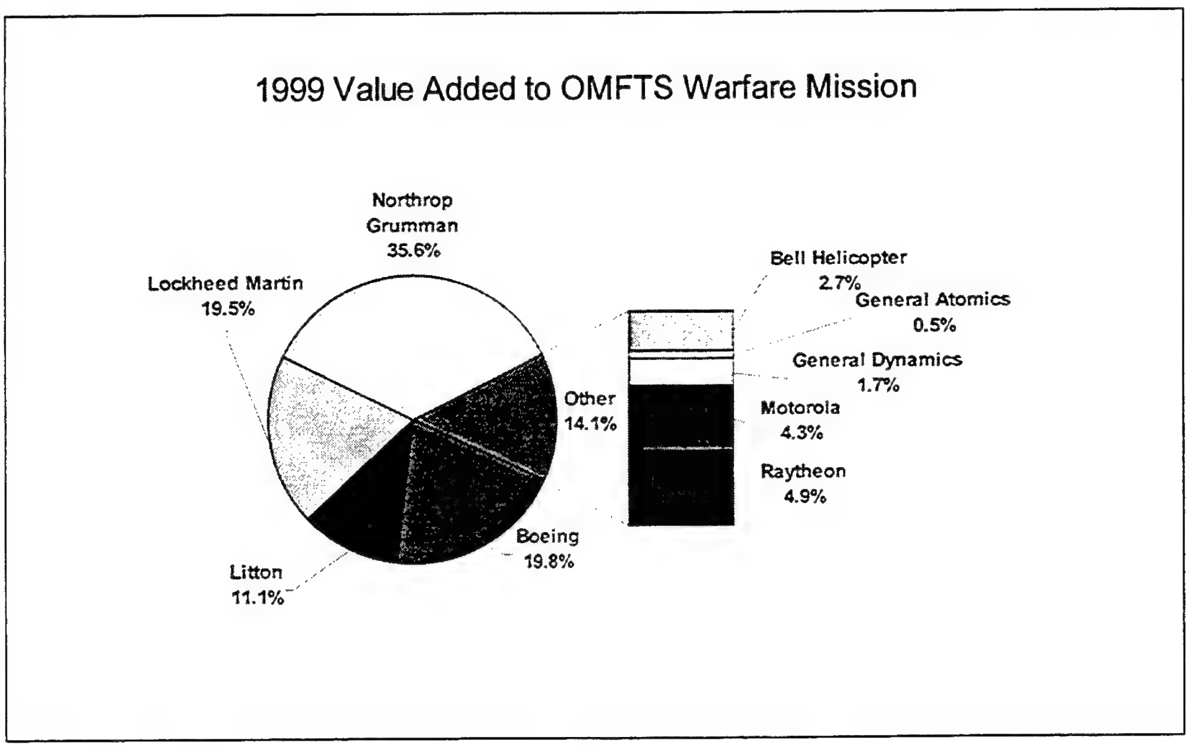

Figure 17 OMFTS Prime Performance Developed by Researcher

C. THEATER AREA DEFENSE

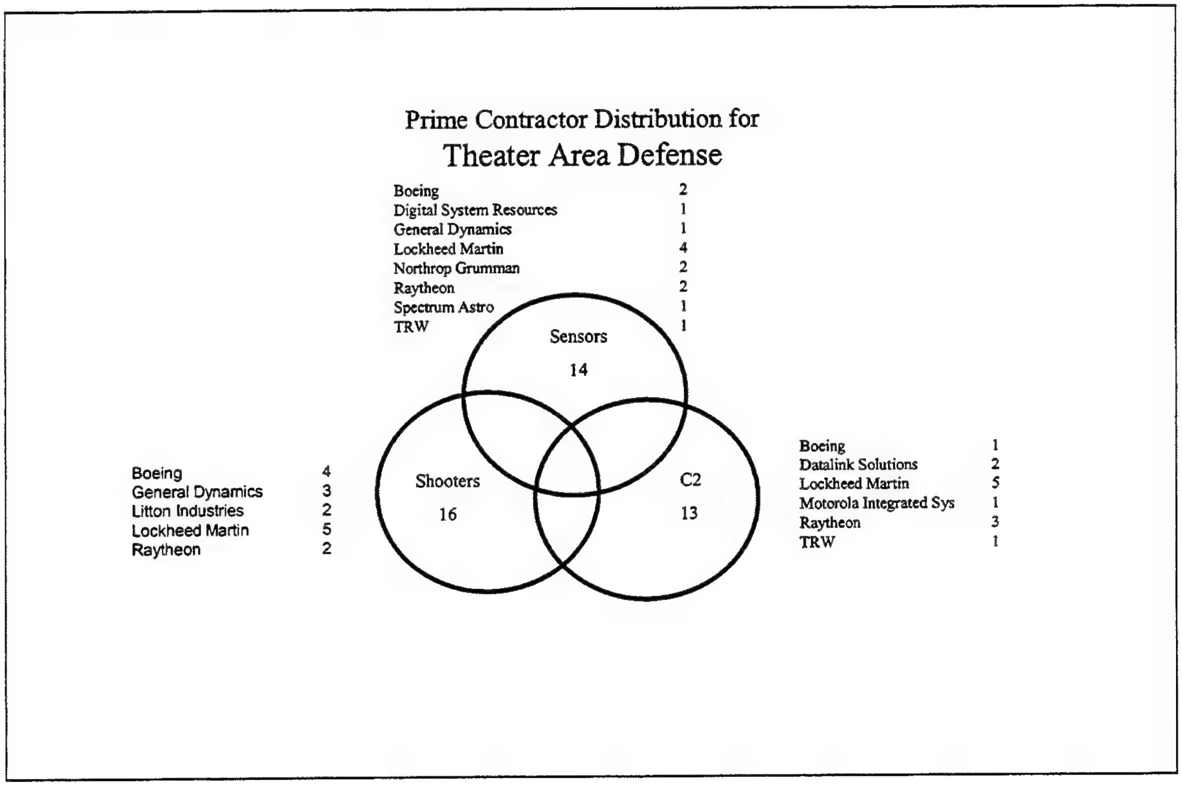

Figure 18 TAD Industry Concentration Developed by Researcher

Three prime contractors have significant presence by holding prime contracts in all three lobes of this warfare mission. Lockheed Martin holds four sensor programs, five C2 programs and five shooter programs. These programs range in diversity from satellite communications and aircraft development to undersea sensors and ship communications. Boeing's presence throughout this warfare mission is primarily a representation of its traditional aircraft development expertise, exceptions being its DD-21 and NAVSTAR involvement mentioned above. Raytheon's programs in the sensor and C2 lobes are technology and software intensive programs. Its shooter programs are also traditional

Raytheon programs in that the missiles are heavily dependant on inputs from Raytheon developed C2 and Sensor programs. Northrop Grumman like in OMFTS has a concentration of programs in the sensor lobe. TRW's involvement in TAD is limited to one C2 program FAADC2I, a software intensive program, and their participation in the Engineering Manufacture and Development (EMD) competition for the Space Based Infrared System (SBIRS) Low program. Again, General Dynamics and Litton industries have a significant presence in the shooter lobe due to their acquisitions of shipbuilders.

The active contracts for this warfare mission total $64.1 Billion. Lockheed Martin and Boeing split 75% of the active contract, $26 Billion to Lockheed Martin and $21 Billion to Boeing. The next closest holders of the revenue share are the shipbuilders with a combined value of $10 Billion. As a comparison, Raytheon with seven relatively mature programs with presence in each of the lobes has only a slightly greater revenue stream than Litton industries' two programs in only the shooter lobe. The DD-21 program still being in the concept phase with only $168 Million in open contracts, compared to a mature DD-51 program with $1.7 Billion, further accentuates the difference between these firm's revenue streams.

Again, lack of shipbuilder performance data skews the data representation of contractor value added. Thirty percent of DoD's 1999 budget for TAD related programs were for development or production of ships. The remaining firm without performance data, Digital Systems Resources, is the prime contractor for the SURTASS ship to shore integration which accounts for less than one half of one percent of the 1999 budget for TAD mission related programs. Of the remaining DoD investment ($7.9 Billion), the six prime contractors provided $2.5 Billion of value added performance. Boeing was the

significant contributor to TAD in 1999 with 37% of the value added performance. Lockheed Martin's multiple programs in all the mission functions and large total revenue stream only provided 22% of the value added performance in 1999 compared to the 26% value added contributed by Raytheon's C2 and Sensor associated programs. Northrop Grumman's tight focus on sensor programs result in a small portion of the value added in the TAD warfare mission.

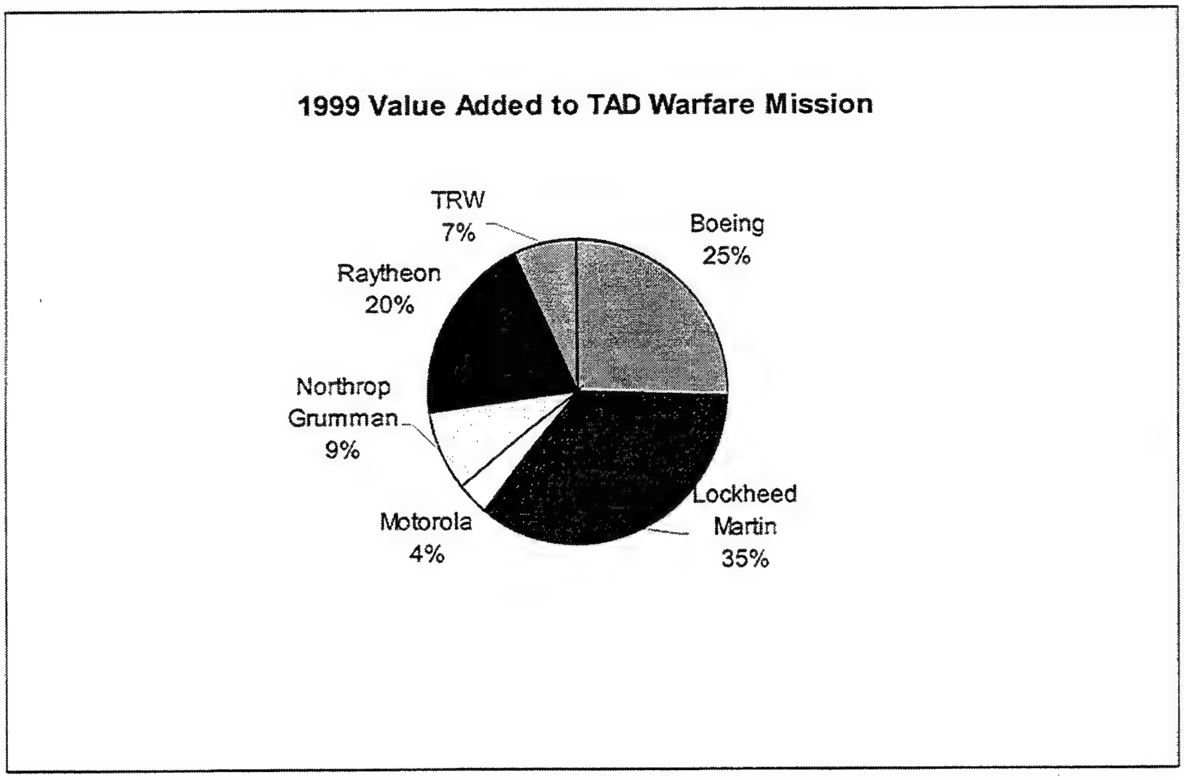

Figure 19 TAD Prime Performance Developed by Researcher

D. DOMINANT MANEUVER

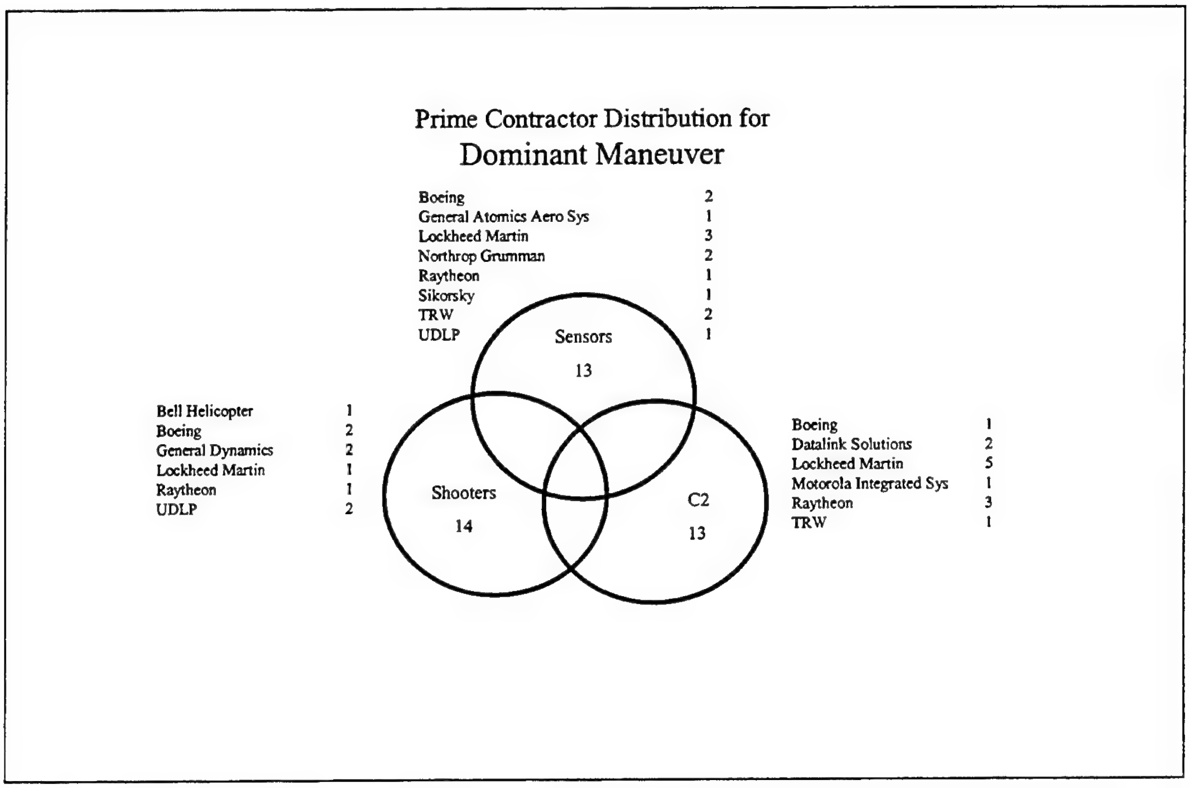

Figure 20 DM Industry Concentration Developed by Researcher

The prime contractors with significant positioning in dominant warfare are the four major defense firms, plus TRW and UDLP. Boeing's presence reflects its traditional expertise with air and space prime contracts. Lockheed Martin exploits its traditional niche in development of C2 and sensor systems. Its presence in the shooter lobe comes from leading the international development team competing for the Future Scout program. Although Raytheon has a presence in all three lobes of the warfare mission, with three C2 programs, its concentration is in technology-based programs. Raytheon acquired its sole shooter program (ERGM) through the acquisition of Texas Instruments Weapons Systems division. UDLP maintains its presence in this warfare mission through

its tracked vehicle programs, Crusader and the Bradley family of vehicles. It is also competing for the next generation sensor vehicle, Future Scout, by leading an international development team. General Dynamics holds a presence in the shooter lobe through the M1A2 and AAAV programs. General Dynamics is a contributing member to Lockheed Martin's Future Scout team through a joint venture with Vickers Defence Systems. Northrop Grumman's key prime contracts for the JSTARS and Global Hawk programs continue to give the company significant presence in the sensor lobe.

The active contracts for this warfare mission total $30.8 Billion. Boeing, Lockheed Martin, and Northrop Grumman share 73% of the revenue stream. In addition to the overstatement of the revenue stream due to Lockheed's overlapping Satellite programs, 50% ($670 Million) of its MLRS active contracts are attributed to direct foreign sales to six countries since March of 1999. Boeing continues to maintain its significant presence through its aircraft programs. Northrop's JSTARS and Global Hawk programs maintain the company's position as a significant prime contractor in the sensor lobe. UDLP is in a similar position to Lockheed Martin in that its vehicle programs are in an overlap stage, albeit at a much smaller scale. The open contracts for the Family of Bradley vehicles are for technology maintenance and the FCSC contracts are comparatively small initial funding contracts for the competition between UDLP and Lockheed Martin. TRW's Guardrail contract is one of the few instances were an inconsistency exists between the 1999 budget data and either program integrator report or the Infobase Publisher's database. The 1999 budget is for $62.3 Million, while the Infobase database reports the active contracts to be only one million dollars. Although

TRW shows a significant presence in terms of position, its revenue stream is less than one half of one percent of the total warfare mission's active contracts.

The distribution of prime contractor value added for this warfare mission identifies the cyclical nature of supporting warfare missions. Boeing and Northrop Grumman's aircraft programs are in production. The Comanche program has just entered the EMD phase of development with a $3.1 Billion contract and increased activity due to the production of 13 aircraft for both EMD and operational testing. [Ref. 71] The Longbow Apache is in mid production with the first upgraded AH-64's delivered in 1997. [Ref. 110] The AV-8B's are in the midst of a service life extension plan (SLEP). Finally, the JSTARS program is in its Low Rate Initial Production (LRIP) phase. These upgrade and production activities account for almost 75% of the prime contractor value added to this warfare mission. The unavailable data on General Dynamics' prime contractor performance for the M1A2 Abrams prevents gathering supporting data from a contractor in a similar situation. The M1A2 is currently going through an upgrade and the AAAV is in the midst of its demonstration and validation phase with three production models. The C2 core systems and combat vehicles for this mission, on the other hand, are either experiencing low investment maintenance activity or initial analysis of alternative investments shared between competitors. In 1999, Lockheed Martin and UDLP have a combined value added of only 13%.

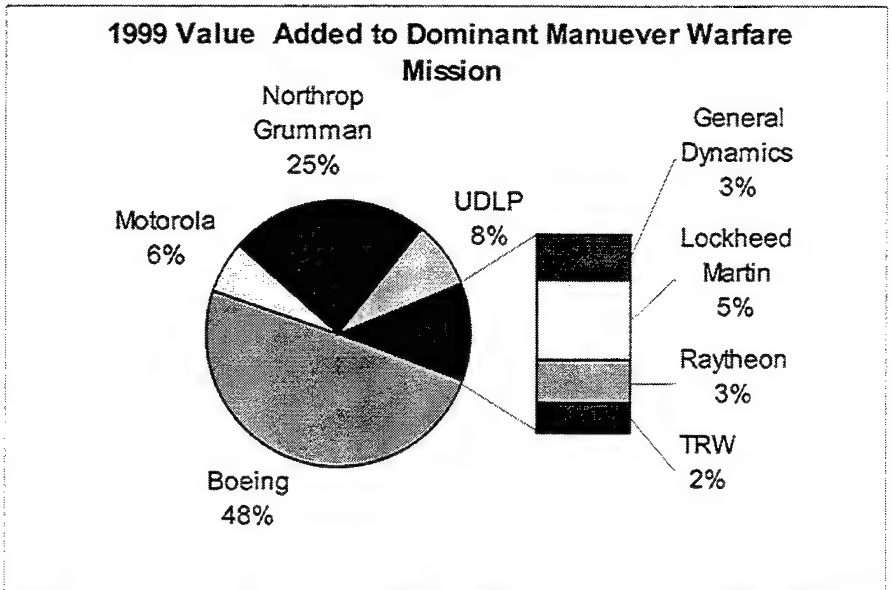

Figure 21 DM Prime Performance Developed by Researcher

E. PRECISION STRIKE

The Precision Strike warfare mission is most referred to in network centric discussions. Of all the warfare missions, precision strike is the closest to achieving a true network structure. The industry data provided on this mission may provide the best insight into adjustments to the new environment. First with twenty shooter programs, DoD is investing in multiple ways to execute the mission. Boeing, Lockheed Martin, and Raytheon again have presence in all three functional lobes. Northrop still has a significant presence in the sensor lobe and is also represented in the shooter lobe with the B-2. Boeing adds missiles and guided munitions to its aircraft and space base. Four of Boeing's programs in the shooter lobe are missiles or bombs that use information from

aircraft or GPS in performance of their mission. Lockheed Martin's presence in the sensor and shooter lobes mirrors the Boeing structure of aircraft and missile programs.

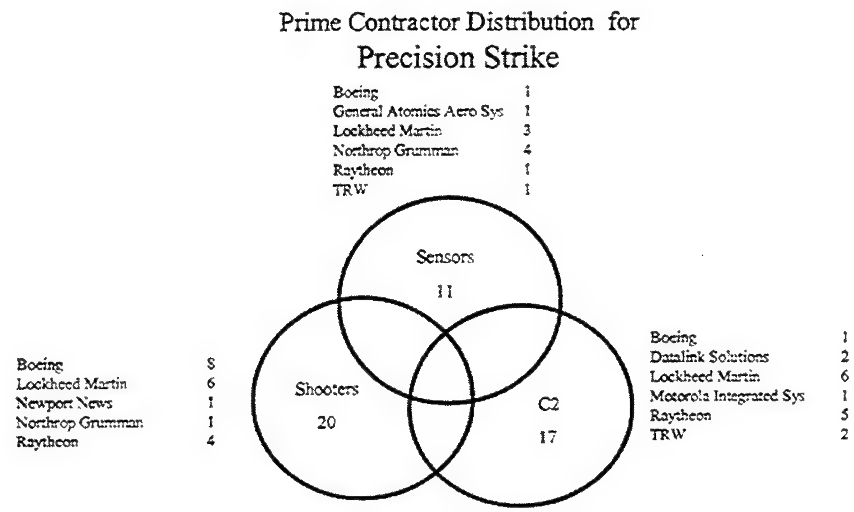

Figure 22 PS Industry Concentration Developed by Researcher

Lockheed again maintains a strong presence in space based C2 programs. The shooter lobe is the only warfare mission where Raytheon has a significant presence. Raytheon has four missile programs. Additionally, Raytheon is represented in the C2 lobe with its sole aircraft prime contract, Rivet Joint.

The total active contracts for this warfare mission equal \$64 Billion. \$16.7 Billion of this value is attributed to direct or Foreign Military Sales of the F-16. Half of Lockheed Martin's active contract value in this warfare mission is attributed to foreign sales of the F-16. The F-16 contract sales are comparable to Boeing's, the second largest

firm in this warfare mission, with total active contracts at $17 Billion. Northrop Grumman's $6 Billion JSTARS program is bolstered by the $4 Billion of active B-2 contracts and give the company claim to 19% of the revenue stream. Raytheon again, despite a significant amount of program presence, has less than 5% of the revenue stream.

The value added data is skewed due to insufficient prime contractor performance data on key programs. Also, Joint Strike Fighter data is source selection sensitive and thus unavailable.

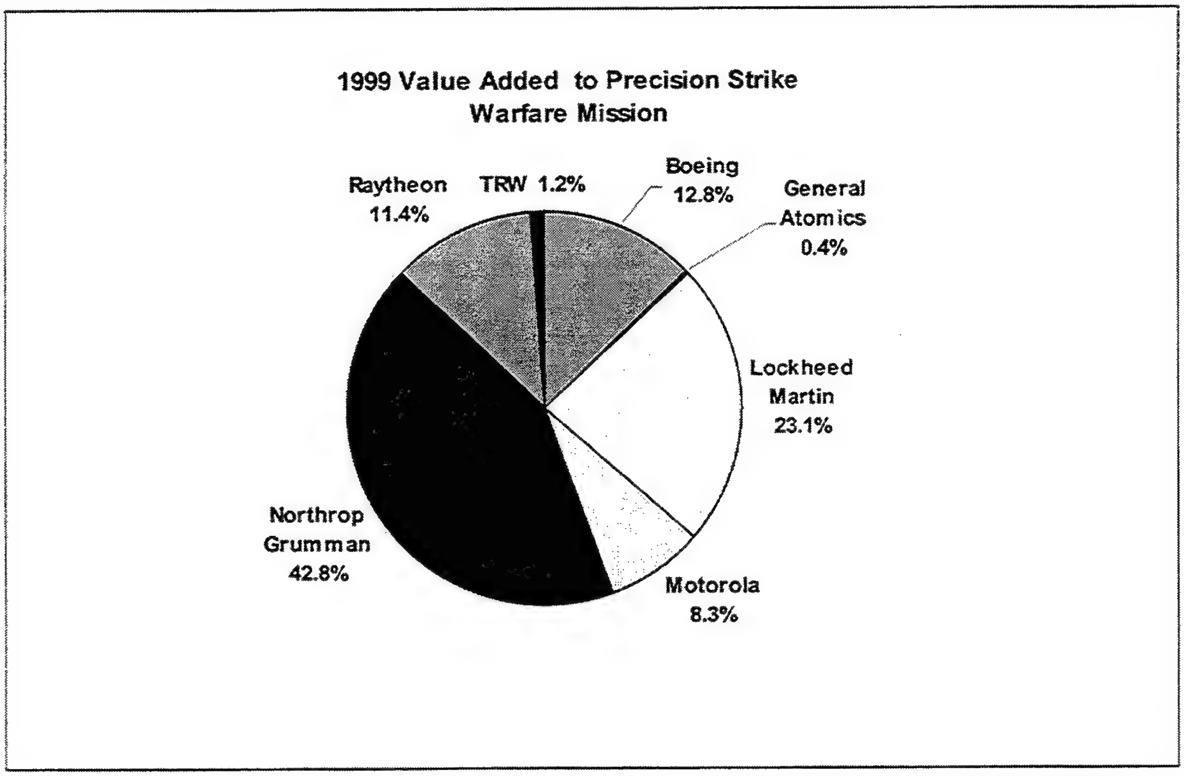

Figure 23 PS Prime Performance Developed by Researcher

Other unavailable key elements concern the F/A-18 E/F program, the CVN-77, and ATACMS. These absences appear to cause an understatement of the value added performance by both Boeing and Lockheed Martin. With $3.2 Billion of 1999's budget

associated with Boeing's F/A-18 E/F, the understatement of Boeing's position is much greater than that of Lockheed Martin's. Lockheed Martin and Northrop Grumman have comparable percentages of the prime contractor value in 1999. An adjustment of Boeing's value for the absent data would put it on the same level as Lockheed Martin and Northrop. Raytheon with less than 2% of the available revenues applied 14% of the value added performance in 1999.

F. INDUSTRY ANNUAL REPORTS

This section reviews the annual reports for the four largest firms. The review focuses the firm's current strategy through the CEO's comments and heralded achievements in their letter to the shareholders and business report.

1. The Boeing Company

Boeing's letter to the shareholders depicts a company intent on creating shareholder wealth through exploiting its integration skills and expertise. The report states, "In a year filled with big events and changes, one of the biggest was this: We stopped thinking of ourselves as just an aerospace manufacturer and began to think of ourselves in a much broader way as a provider of integrated products and services to all of our customers." [Ref. 7 p. 3] The report credits the company's integration skills and state of the art assembly processes with winning major space and defense contract competitions in 1999. [Ref. 7 p. 2] In closing, the report states that the company expects to improve its strategic position through continued refinement of existing process and moving into new growth markets.

2. Lockheed Martin Corporation

Lockheed Martin's letter to shareholders focuses on accomplishments and the company's plan to reduce debt. The plan states that the company will focus on its core competencies, which are Aircraft, Space Systems and Integration Services. The systems integration segment witnessed a 9% increase in its order backlog, reaching $15 billion. This backlog is the highest of any of the company's business units. The report stated that the increase were due to 50% increases in missile integration contracts and 50% platform integration services. [Ref. 59 p. 25]

In a speech before the Atlantic Council and the Center for European Reform Mr. Vance Coffman, CEO of Lockheed Martin gave a summation of his view of the defense industry. He stated,

> Our "market" is driven by military requirements, and our products are intimately tied to the directions that NATO and Allied militaries wish to go in the future. That future will increasingly be one of information-based strategies, including networks that link "sensors and shooters," integration of ever-more-complex systems, and delivery of all this information to the commanders who need it, whether in national decision making centers, in cockpits, or on the battlefield itself. In other words, the provision of integrated systems of sensors, platforms, weapons and knowledge – so-called network-centric solutions – will be key products of our industry [Ref. 18]

3. Northrop Grumman Corporation

Northrop Grumman's CEO, Kent Kresa, opens his letter to the shareholders with a discussion of the revolution of military affairs. He further states that Northrop has been positioning itself for competing in a network centric defense environment. The letter to shareholders discusses two specific requirements, sensor technologies and Unmanned Aerial Vehicles (UAVs). In this discussion, Mr. Kresa mentions prime integration

capabilities and key subcontracts for the F-16 program (sensor contract) and the F/A-18 E/F program (aero structures contract). The company's report on Logicon, its information services segment, indicates pursuit of both a strong subcontractor base to leverage its prime contracts, as well as diversification. Logicon is a key subcontractor for the Aegis system, and holds complementary contracts for support services to the warfare centers. Additionally, it is using its information systems core strength to capture economies of scale through business in both state services and health care sectors. Northrop Grumman is creating similar synergies in its other sectors. Its Electronic Sensors and Systems Sector is a subcontractor for both the gold and blue teams on the DD-21 contract and the company is championing its JSTARS and E-2C Hawkeye contracts as indications of things to come.

4. Raytheon Company

Raytheon's letter to shareholders focused on a disappointing year in 1999 and a commitment to remain as the leader in defense electronics. The company has reorganized by teaming its defense electronic sectors producing commercially marketable products with the rest of its commercial sector. The company intends to build on its existing relationship with DoD to create synergies with commercial sales, plus innovation in optics and RF technology. The company reports its strength to be a pioneer in data fusion technology and network centric command and control systems. It will use this strength to capture the upgrades of existing platforms to meet the network centric requirement.

G. INDUSTRY SUMMARY

The key **players** in the industry for network centric warfare are the four largest firms. Boeing, Lockheed Martin, Raytheon, and Northrop Grumman have significant presence in every warfare mission. Except for OMFTS, they have captured greater than 70% of the revenue stream for each of the warfare missions. Their combined value added performance is greater than 70% for every warfare mission; in the cases of Precision Strike, their value added performance is over 90% of investment.

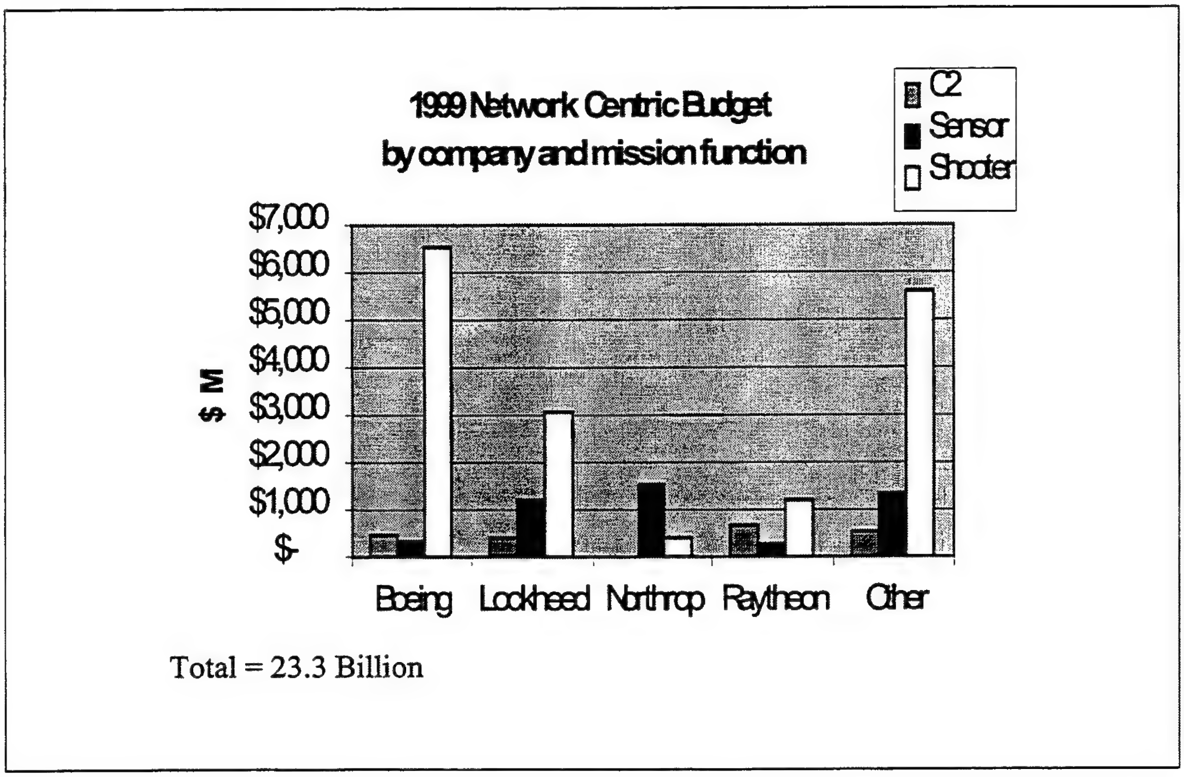

Figure 24 Prime Concentration by Mission Function Developed by Researcher

The firms are establishing positions across each of the warfare missions. Lockheed Martin and Boeing are expanding to non-traditional platforms through technology integration contracts. The smaller producers that have established niche

markets in shipbuilding, sensor development and armored vehicles are teaming with these **players** to maintain their presence in the industry.

The **Rules** for the industry are those established by DoD.

Technology capture and interoperability.

For the most part the key **players** in industry are responding to DoD's push for competition at the component level by leaving the segment. The firms are doing less component building and more component integration. They are funding joint projects with dual use firms and leveraging the resulting innovations. This **Tactic** is being employed by three of the four firms. Raytheon is still holding on to its electronics excellence as a competitive tool and challenging commercial component builders with abilities in specialization markets. Another **Tactic** employed is the staking of claims. The firms are capturing system presence that is potentially advantageous when the competition for plug and fight interoperability matures. Any such advantage rests on ability to solve the future problem of interoperability and coupling of system architecture with operational doctrine.

The **scope** of the relationship between DoD and the industry is divided into three parts in accordance with the levels of architecture. At the top level, platform structure, **scope** is reduced except for potential growth in international sales. The middle level or the architecture development has tremendous potential for growth, since the interoperability requirement requires adjustments to methods of doctrine and system coupling. The lowest level, components, has tremendous growth due to the short life cycle of the technologies. It also has potential for considerable competition growth and

instability (From a firm's perspective) as COTS and Open Systems architecture practices take hold

H. DATA PRESENTATION SUMMARY

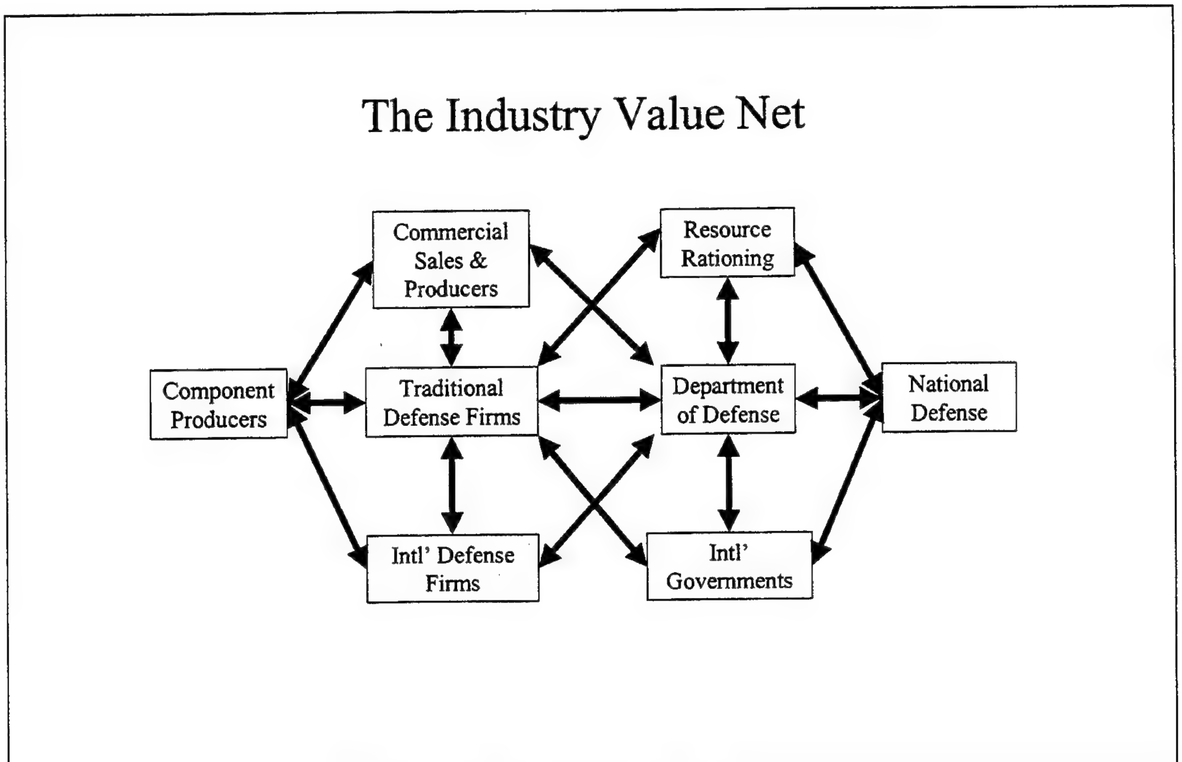

Figure 25 Value Net Forces Recap Developed by Researcher

The complexity of the influences on the traditional defense industry creates a daunting problem for those seeking to clarify the picture without diluting the robustness of the data. The industry data and, in particular, the strategic statements in the 1999 annual reports indicate that the key **players** are reacting to DoD's signals. The firms are structuring themselves for competition at the system of systems level. They are developing synergies between platform development and information systems

technologies. The international market poses a potential for growth, as well as a threat of new entrant competition. Additionally, the firms hope to leverage commercial technologies into economies of scale. Boeing, Lockheed Martin and Northrop Grumman seek to apply their integration skills in new markets. Raytheon intends on competing with the commercial technology market with its electronics component capabilities. The competition at the integration level gives the supplier base increased value especially in the electronic technology sector where capacity is limited and demand growth unprecedented. Finally and most importantly, the shift to open architecture systems and the reduced scale of platform structures is forcing the competition between systems to the integration of plug and fight demands with doctrine driven architecture and processes.

V. ANALYSIS

A. INTRODUCTION

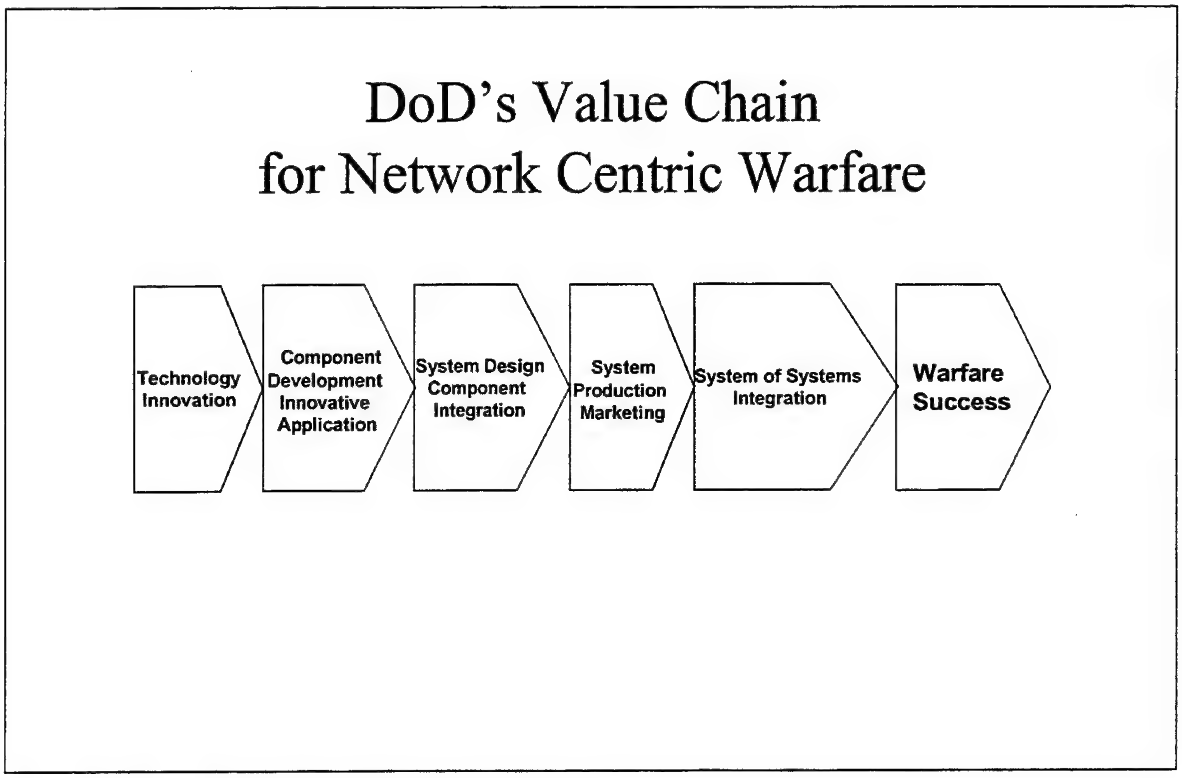

Figure 26 DoD Value Chain Developed by Researcher

The analysis of the industry starts with a general view of the Value Chain for successful network centric operations. DoD's many visionary documents have two common themes. The force of the future will rely on its networked abilities and technological advancements will enable the transformation to the future force. The 5000.2 and dual use program guidlines establish that the transformation will be an iterative process. The emphasis on technology insertion and rapid evolution define the foundation levels of the value chain. The remainder of the chain rests on the integration process either at the weapon system or system of systems level. This value chain is a

broadband look at the value builders for system of systems production. Inside each of these arrows, one would find the industry firms using strategic mechanisms such as low cost, economies of scale, or product differentiation to build their value to the chain. The performance and position a firm establishes in the industry dictates its ability to strategically compete along the value chain. The data have shown there is a strong link between a firm's prime contracts and its strategic plan. The industry analysis identifies where the key firms are attempting to create value and where there is opportunity for competitive advantage. Finally, as a cautionary note, the leap from system of systems integration to warfare success does not mean interoperable systems are sufficient for warfare success. Corporate system of systems integration does not include strategic planning, operational skill, and systems interoperability. The Value produced by the Industry development of systems can only speak to the interoperability of the systems and their ability to meet the requirements of DoD's warfare doctrine. The strategic and operational value of the system of systems employment rests solely on DoD's warfare planners.

The next step of the analysis is to determine which portions of the value chain have the greatest importance for the key **players** in the industry. This research focuses on the **rules** and **tactics** of the key **players** to determine where they are placing value. For instance, the key **players** in DoD have used the performance specification and open systems **tactics** to eliminate proprietary claims to technology and component development. DoD is, therefore, placing a higher value on rapidly inserting advanced technology and components than on design to specifications or discrete technologies. Starting with DoD's influences, this chapter layers the value building or restricting

requirements each external node of the value-net places on the network centric warfare value chain. The final picture of the value chain points out the strategic environment within which the key **players** of the industry must compete.

B. DEPARTMENT OF DEFENSE INFLUENCES

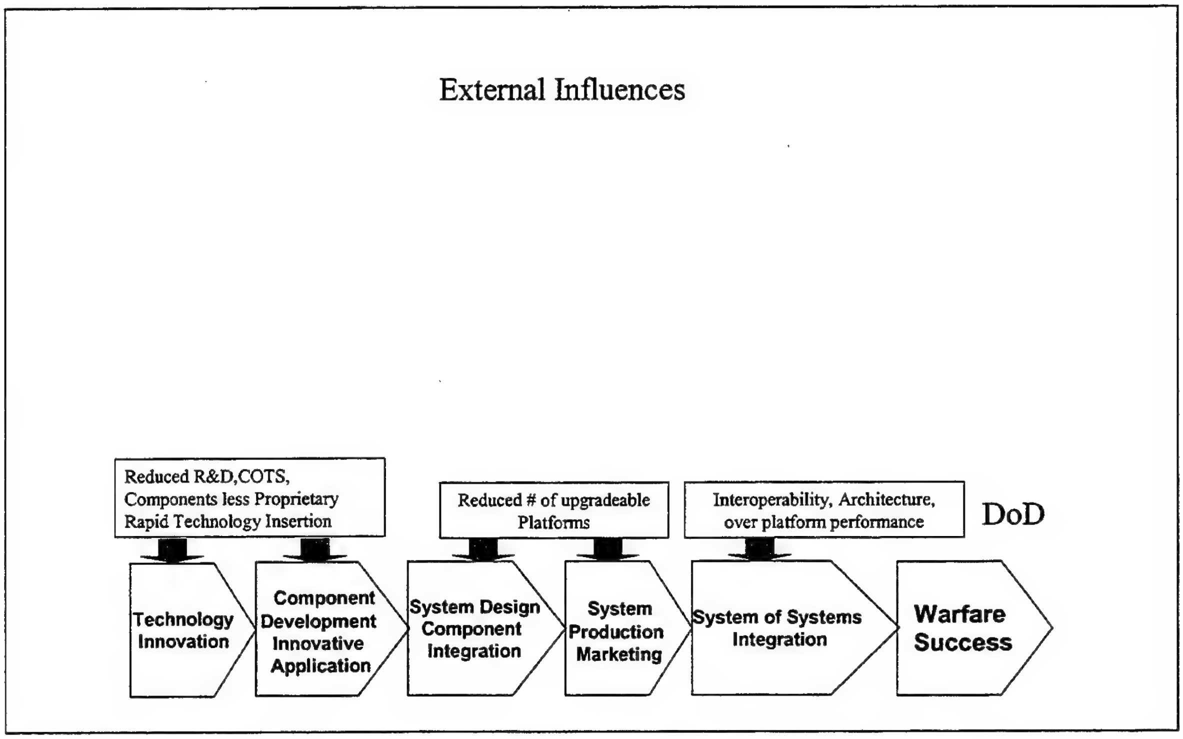

Figure 27 DoD Influences Analysis Developed by Researcher

1. Technology Innovation and Component Development

Innovation rapidly converted into an application creates the most value at this phase of network centric warfare's production. DoD, however, cannot fund R&D at the required levels to support an in-house capability robust enough to match the speed with which innovation occurs in the commercial sector. DoD is resolving this mismatch by attracting commercial firms, with their R&D resources and large scale production, to enter the innovation and component development market. The shift to performance

specifications, open architecture and the revised plan for major systems procurement detaches the source of technology innovation from the program manager and proprietary designs controlled by the prime contractor. This reduced control promotes the entrance of commercial firms as competitors for the lower levels of weapons systems development. It also provides an opportunity for those primes with subcontract management skills and capital to create the necessary alliances for successful technology insertions. Those prime contractors that desire to continue making defense systems from the component level up must build a commercial outlet for their components. They must obtain the economies of scale for their R&D and production to maintain a Maximum Efficiency Scale comparable to the commercial sector. The researcher bases this opinion on the scale of the commercial communications and semiconductor markets versus the DoD market for the same products. By removing the proprietary protection on systems that require these components, DoD is giving the firms that choose integrating commercial technologies over building their own at least a cost advantage, if not a technology edge.

Tapping into commercial technology creates an access to the commercial products that emanate from the research. To reconfigure the commercial technology into a defense specific product would be to lose the economies of scale created by commercial production. As shown by the TRW pilot production case, a production line producing 1500 units would have a much greater economy of scale than a run of a two hundred. In essence, DoD is seeking to capture technology and components with only a 36-month life cycle. Rather than invest in custom design technologies that are susceptible to obsolescence, DoD would rather make incremental investments on open technologies that are upgradeable. This fact ties in with the Defense Science Board on Vertical Integrations

finding that; "Continuous change in missions and technologies for defense systems makes fixed, in-house investments in supply (component or subsystem) subsidiaries risky". [Ref 32 p. 26] Additionally, the DoD Directive 5000.2 requires that the concept technologies be tested and mature before their implementation into system development and production projects. The use of commercially applied technology satisfies this requirement without additional testing and validation.

2. System Design and Production

There are two major aspects for these levels of warfare development. First, the "constrained budget" and "no peer competitor" environment signals reduced production lines for capital assets. DoD values a smaller more lethal force, which they will produce through recapitalization programs and technological evolution. Second, the system design has architecture implications for system components and for operational requirements. The tight coupling between system architecture and operational doctrine is a significant source of value for the prime integrator. This raises the importance of weapon systems contracts beyond the expected production quantity.

The testimony concerning Army recapitalization, the numerous service life extension programs and the policy statement stressing value created by upgrading information dominance systems vice building new platforms are signals for reduced production lines. Internal efficiencies such as the consolidation of the early 1990's, the use of acceptable COTS components and the sharing of R&D costs will reduce the Maximum Efficient Scale (MES) of platform production, however, It is these are enough to compensate for reduced demand. Both Production rates and the number of different

systems are shrinking. The Joint Strike Fighter with its multiple configurations is intended to replace fighters, attack, and Vertical Takeoff and Landing (VTOL) aircraft. It is touted as the last major aircraft production for years to come. If the prime contractor desires to hold on to large production facilities as a core competency, it must be ready to support the infrastructure with non-DoD work.

The systems development level of the value chain is where open architecture requirements meet operational demands. The conflicts that brought about the CEC Integration Task Force suggest a widespread coupling of doctrine and system architecture through the software code as a solution. This fusion of doctrine into design creates a proprietary connection to the systems architecture. As a result, prime integration contracts have significance beyond their potential revenue stream. The program's value to the entire network creates complementary attributes for the production of both system upgrades and complementary systems in the network.

The Joint Technical Architecture initiative has successfully promoted use of commercial technologies developed in the concept stage, and rewards designs that insulate components from the system architecture as in the F-22 design. As a result, growing use of open systems architecture, COTS components, and commercial R&D is effectively isolating the component level from the platform architecture or achieving plug and play capabilities. This modular design, however, separates the prime contractor from future revenues tied to incremental performance increases made at the component level. A fully isolated component system means that upgraded components would be universally compatible and require zero changes to the total system for insertion. Ideally, DoD would be able to purchase an upgraded unit for the F-22 direct from the component

producer and install it without requiring prime contractor involvement. The fusion of doctrine and systems architecture, however, prevents this from occurring.

The increase in component capacity created by the technology advancement, however, is an opportunity for process improvement. It's in DoD's interest to change processes and operational architecture to capitalize on technology enhancements. The desired changes in process affect the marriage between doctrine and architecture. Enhancements to architecture are strictly in the domain of the prime contractor. The proprietary software code addresses more than the presentation and transfer of the battlespace and system information, but also the content and the human and system reaction to the information. The faster processing enabled by technology upgrades creates a natural demand for more content. The definition of the new content and how the system would obtain or process it requires changes to the systems architecture software. This additionally must be coordinated with the user who will dictate what additional content adds value to the system. Therefore, proprietary systems architecture is a natural barrier to entry for upgrade competitions. The prime contractor, who captures the initial development contract for a weapon system, has a distinct advantage through its knowledge of the link between doctrine and system architecture. Through its proprietary knowledge, the prime will have the integration responsibility for all subsequent technology refreshments.

3. System of Systems Development

The prime contractor's control over the systems architecture/doctrine fusion has a direct impact on the interoperability requirements put in place by the 5000.2, CJCSI

3170.A1, and the 6212.1B. The researcher suggests that since it took a task force of 300 personnel to recommend changes to the Aegis Advanced Combat Directional Systems (ACDS) and Command and Control Processor (C2P) systems to allow their successful linking through CEC, meeting interoperability requirements defense wide is the new market for prime contractors. The Software Engineering Institute at Carnegie Mellon suggests there are economies of scale in architecture development. In a brief to the eighth PEO/SYSCOMS Commander's conference, Ms. Linda Northrop, Director of their Product Line Systems Program, stated that the architecture development processes are easily reused across similar requirements or product lines. [Ref. 72] Integrating firms can convert core competencies through engineering knowledge, system experience, test plans and documentation competitive advantage. in interoperability

C. SUPPLIERS AND COMMERCIAL FIRMS

In his paper on the history of dual use technology, Mr. Jay Stowsky suggested that the dual use initiatives of the 1990's gave the traditional defense firms cause for alarm. A General Accounting Office analysis of section 845 other transactions and a review of active dual use technology contracts prove otherwise. The very low percentage of commercial firms acting as prime contractors in either program indicates that the firm's are not actively competing with traditional defense firms. Whether it is due to profit incentive (5.4% average return on Aero/Defense revenues, 14.2% return on Network system revenues, 9.4% on Communications equipment revenues) [Ref. 94] or an aversion to Federal Acquisition Regulation, the commercial firms would prefer to subcontract through a defense company than work directly for the Government. This fact has strategic

make or buy implications that hinge on the cost versus control issue. By scaling back the in-house component or sub assembly development capabilities and relying on commercial suppliers for technology advancement the prime saves considerable infrastructure costs. Its versatility and speed as a developer rests on its ability to recognize innovative producers and integrate the new technology with their processes. The price for the flexibility and potential infrastructure reduction is the loss of proprietary control of the technology. As was shown in the semiconductor markets, the commercial demand for technology products is outpacing supply. Without an in-house production facility, the defense prime is subject to the prices and availability of the market place.

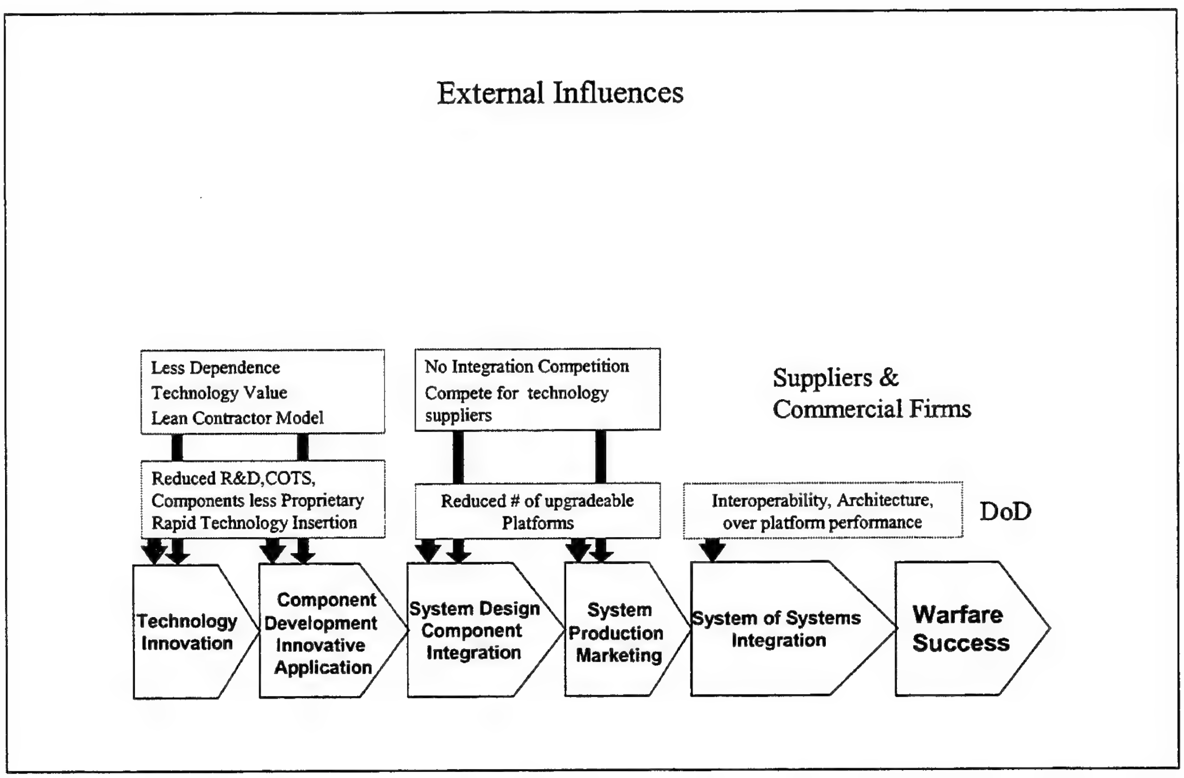

Figure 28 Commercial and Supplier Influences Developed by Researcher

As stated above, the involvement of the commercial firms and suppliers have accelerated the conversion to open systems type architecture. Again, the compatibility of

hardware systems has not eliminated the primes proprietary barrier created by the doctrine/systems architecture fusion. In this regard, even if the commercial firms desired to compete for prime integration contracts they would have a steep learning curve in terms of defense doctrine.

D. INTERNATIONAL GOVERNMENTS AND SUPPLIERS

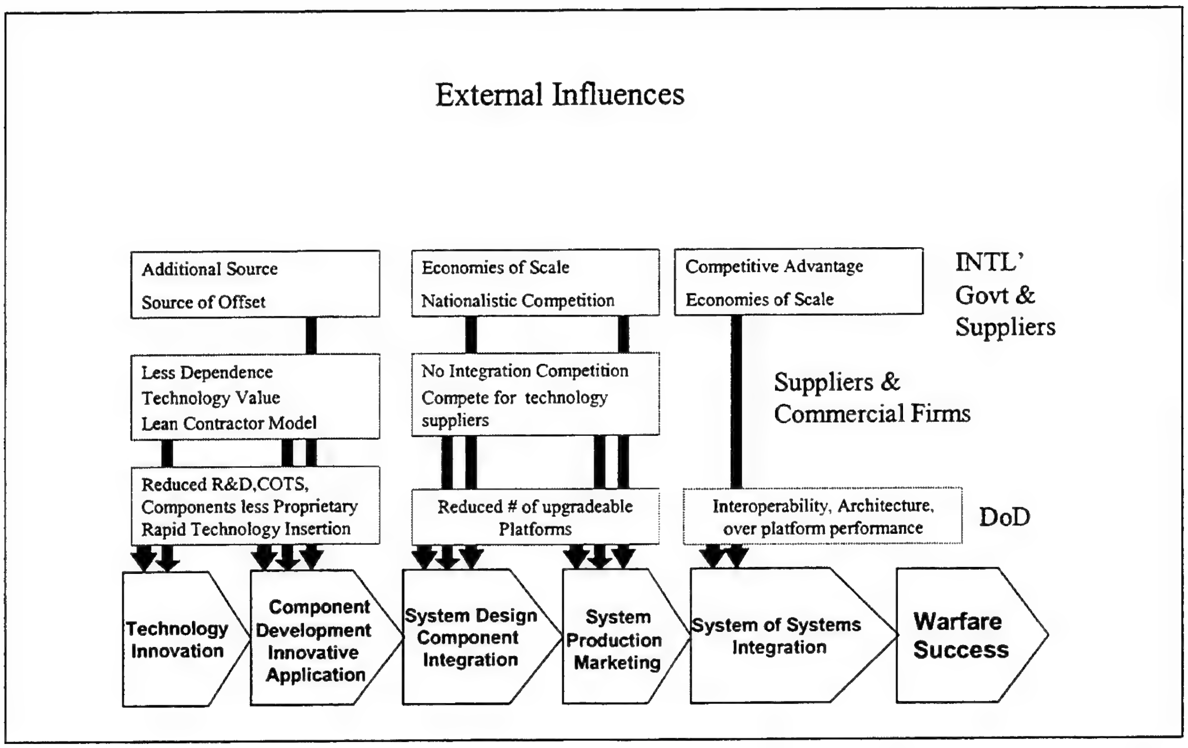

Figure 29 International Influences Analysis Developed by Researcher

1. Technology Innovation and Component Development

The traditional defense firm's decision to build components in-house or subcontract determines the impact of international suppliers on their strategic position. Subcontracting again shows more strategic promise. First, it increases the number of potential suppliers. Second, the subcontracts are sources of offset compensation

increasing the desirability for the prime's product. The historical presence of co-development and joint ventures across the Atlantic is evidence of the feasibility of inserting foreign developed components. The increased international activity at the component level suits the COTS and technology insertion model. The prime contractors who choose to subcontract vice develop benefit from competition-induced pricing and innovation. The ability of a firm to create an offset out of component developments will additionally, meet a Foreign Military Sales need without diluting proprietary capabilities.

2. System Design and Production

Foreign sales is a way a firm may compensate for the reduced U.S. arms purchase and maintain their MES for production. With Foreign Military Sales (FMS) toping $12 Billion in 2000 and the allied defense budgets on the rise, there is growth potential in the foreign markets. Lockheed Martin doubled its production of F-16s due to FMS. Overseas sales is consistently a proven market, the question is how much can be sold and will it be enough to maintain production lines. The U.S. military owns almost 50% of all armament systems in the world. Depending on type of system, a mix of five allied nations own another 25% of the world's armaments. The rest of the world shares the remaining 25%. The U.S. industry is perhaps the largest producer of arms, but it is not the only producer. It must compete for sales in a market with buys on a much smaller scale than their domestic production. The European industry is seeking to capture some of the market, and the trend for nationalistic motives among the biggest foreign buyers provides a competitive leveling if not an advantage.

3. System of Systems Development

The push for coalition interoperability is a distinct competitive advantage in the race for Allied recapitalization. As stated above the U.S. has almost half of the armaments in the world, and stands to be the key player in all Coalition responses to aggression. It would follow, therefore, that the U.S. architecture would set the interoperability standard. Both Dr. Gansler and Mr. Coffman, CEO of Lockheed Martin have expressed similar opinions when speaking to Trans-Atlantic organizations. Since, U.S. firms are able to build a competitive advantage through the proprietary fusion between architecture and doctrine, expanding the interoperability requirement beyond U.S. borders only increases those advantages. Lockheed Martin has shown that the firms may expand the interoperability base without extending their production capability. They have established an architectural foothold through their integrated warfare systems contract on the Norwegian's new fleet of frigates. While foreign suppliers have the contract for the ship development. The growing demand for interoperability paves the way for a growth in similar arrangements.

E. SUMMARY OF COMPETITIVE ENVIRONMENT

1. Technology Innovation and Component Development

DoD's plans for iterative movement towards exploiting the revolution of military affairs. This policy favors technological refreshments of contemporary systems, which implies a market whose cycle matches the 36-month life cycle of component technology. The refreshment of both domestic and Allied system components promises market

The refreshment of both domestic and Allied system components promises market growth at the lowest level of warfare development. Weapon system producers look favorably upon signals such as Admiral Cebrowski's labeling technology as a commodity. [Ref. 13] The traditional defense firms, however, must decide if their core business enables competition against commercial firms with R&D capital and revenues that dwarf the defense industry's. Overhead burdened defense firms with small-scale production cannot compete on a unit cost basis with the commercial technology producers. If a traditional defense firm decides to compete, it must either expand its commercial market presence, achieve the economies of scale or differentiate its product enough to demand a premium price.

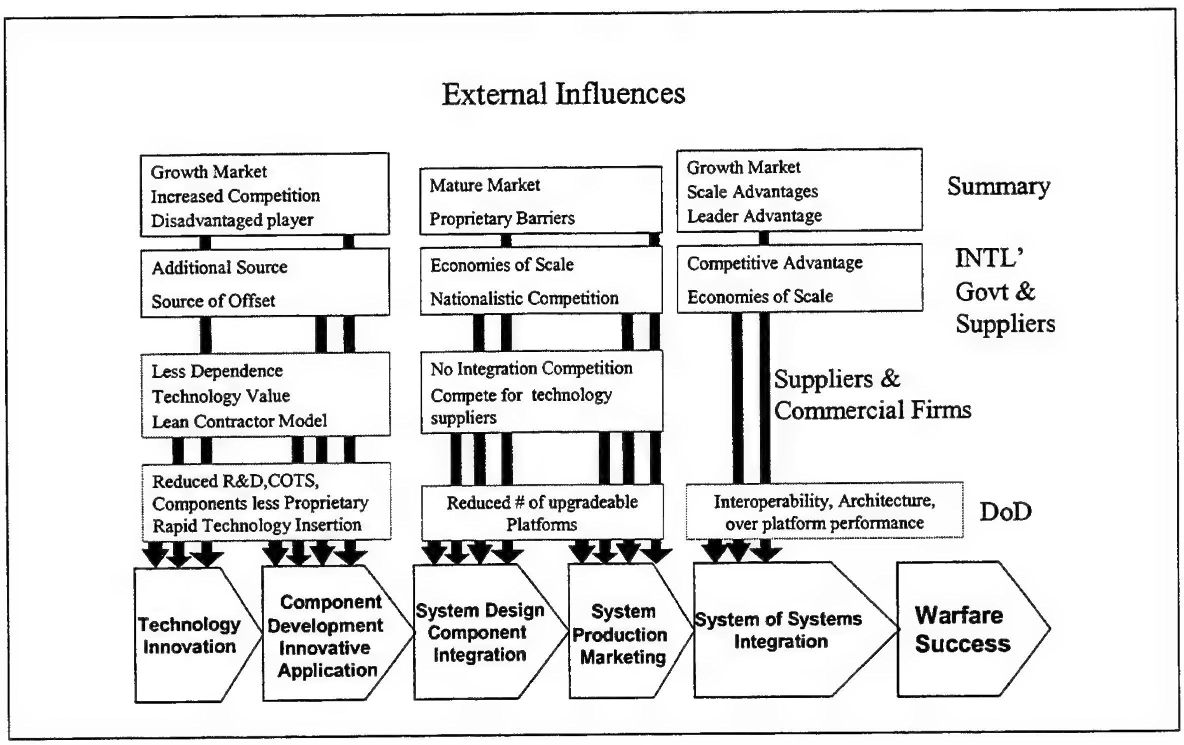

Figure 30 Summary of Influences Analysis Developed by Researcher

2. System Development and Production

The system development and production level is the bridge between the fast-paced component market and the "potentially growing" interoperability market. The strength of the bond between operational doctrine and systems architecture defines the industry's survivability. This level gives the prime contractor a protected foothold in the technology refreshment market. To rely on this foothold based on architecture changes to meet evolutionary changes is a defensive strategy. As with component isolation, technology will eventually break the fusion between doctrine and architecture code. Additionally, the network centric revolution is driving nations to smaller, more lethal forces. This means that although there is an increase in defense spending, the trend for smaller forces will eventually shorten the production cycles. To compete for weapons system production lines is to proverbially, "slice up a shrinking pie". In order to stay in this market, industry **players** must find ways to fill capacity or increase the value of their production assets.

3. System of Systems Development

The signals from DoD key **players** indicate that interoperability is a growth market. Strength of networks depends on the number of connected nodes. To connect a single battle group required a great effort on the part of government and industry officials. The task involved marrying architectures based on naval doctrine. With the added requirement of marrying doctrines from the remaining services, and then allied operations, the complexity becomes daunting. The traditional defense industry firms have an advantage because of their intimate knowledge of the system architecture/doctrine

fusion. Additionally, as indicated by the software engineering institute, the firms gain an economic advantage by increasing involvement in platform integration projects. Firms with significant presence across a warfare mission's three function lobes have an unprecedented advantage in interoperability competition.

F. INDUSTRY REACTION

1. Introduction

This section of the analysis looks at the strategic position of the four key **players** of the network centric industry. It attempts to translate the positions and performance of Boeing , Lockheed Martin, Northrop Grumman, and Raytheon, into a description of strategic intent. This section additionally, highlights and delves into corporate departures from their emerging strategy or uncharacteristic changes in product mix made to achieve the strategy. The discussion addresses the firms individually.

2. The Boeing Company

The Boeing Company's 1999 annual report identified its emergence as a company whose core competency is integrating complex systems. Average prime contract performance of 53% and the characterization of performance on seven of the nine such projects were identified as "integration and design". The company has strong commercial representation in aircraft and space systems development through their commercial aircraft products and their acquisition of Hughes and Rockwell Space Systems. These general characteristics suggest the company is targeting the system development and production market. Their performance across the value chain and presence across the

warfare missions, however, suggest that Boeing's strategy goes beyond the maturing systems development and production market.

Boeing is clearly outsourcing its component development tasks. Only the F-15E, Conventional Air Launched Cruise Missile (CALCM) and the fuselage development for the AV-8B are categorized as component development contracts. The remaining contracts are categorized as integration and design. (The researcher must note here that he and the prime integrators at the Defense Contract Management Centers (DCMCs) considered assembly of the final system as part of "integration and design".) Boeing's involvement in the Dual Use Science and Technology program further illustrates this preference for architecture design over hardware development. Boeing develops designs or validates requirements in four of their five awarded projects.

If Boeing's strategy is to concentrate on the system development market, it should be concentrating in aircraft and satellite programs where its commercial economies provide a distinct advantage. Boeing's movement into the combat systems architecture for the DD-21 and the development of the Long Term Mine Reconnaissance System, are signals of an alternate strategy. Boeing's aircraft and missile contracts give them presence in shooter lobes across all the warfare missions and in each of the services. The AWACS program, however, provides sensor presence in only the land based warfare missions. The DD-21 and LMRS contracts provide the needed access to the sensor to shooter linkage in naval operations. The NAVSTAR program is a misleading presence indicator. It is only a single program, but GPS guidance affects every program listed on the matrix. Additionally, the recently acquired Hughes Space Systems has tremendous presence in satellite communications at the subcontract level. These actions demonstrate that Boeing

is expanding its knowledge of doctrine influencing interoperable systems architecture. This is a strategy for a knowledge base a development of economies of scale for system of systems production and a competitive edge for interoperability integration contracts.

3. Lockheed Martin Corporation

Lockheed Martin's vision statements, CEO representations, and corporate structure indicate that the firm concentrates on integration capabilities over component development. The firm's performance on prime contracts is 54%. The prime integrators categorized eight of the twelve contracts reported as integration and design. The remaining programs were categorized as C2 component development contracts. Lockheed Martin's performance on these four contracts averaged 80%. The firm has additionally established a commercial outlet for information technology through their L3 spin-off, of which they own 35%. Foreign sales are the firm's only economy of scale builder for their system development and production market. They have demonstrated a proficiency in developing foreign sales through their F-16 program. Additionally, Airbus's presence on the JSF team opens the door to further European sales. Although this general structure of the company appears to align them for achieving market advantage in weapon systems sales, it does not fit the maturing environment for this market. Lockheed's presence in the warfare mission and percentage of 1999 value demonstrate a stronger view towards capturing the growing interoperability market. The firm has only 5% value added in the dominant maneuver warfare mission while it averages 25% in the remaining three. The researcher believes this is the reason Lockheed Martin is competing for a land vehicle program. The uncharacteristic development of the Future Scout program gives them

access to the shooter lobe of the dominant maneuver mission, which completes their sensor to shooter presence.

Finally, it appears Lockheed Martin is going a step beyond Boeing in trying to build a knowledge base for interoperable production. It has successfully gained a foothold in the development of the system architectures in the European theater through the Norwegian contract. Additionally, through the JSF interoperability test site in Texas, it has successfully advertised its capabilities for testing interoperable systems. The firm is tailoring the capabilities the Software Engineering Institute suggested as critical for systems development into a system of systems production expertise.

4. Northrop Grumman Corporation

The performance and position of Northrop Grumman as a network centric warfare producer indicate it as a crossover company. The company's 56% prime performance, which is predominantly categorized as "integration and design", indicates that the firm is targeting systems architecture like Boeing and Lockheed Martin. Northrop departs from their strategy, however, by clearly concentrating in the sensor lobe and unmanned vehicle development. This strategy has merit; the information superiority requirement places a high value on the sensor lobe. With just six programs, (five sensors) the firm produced on average 28% of the value added for network centric warfare missions in 1999. Northrop Grumman's unmanned vehicle experience extends beyond their acquisition of Teledyne Ryan. The firm holds the Near Term Mine Reconnaissance System contract and is a major subcontractor for its replacement, Boeing's LMRS contract. To complete Northrop's expertise in unmanned sensor systems, the company acquired Logicon Inc. for

its data management assets. Through this acquisition, it now has an information systems arm with access to commercial economies that provides solutions for the presentation of the large amounts of data its systems promise to collect. If you classify Boeing and Lockheed Martin's **tactics** as acquiring generalist knowledge for total system management, Northrop is seeking a specialist's role in sensor architecture and doctrine marriage.

5. Raytheon Company

Raytheon is the only key player that has not left the component development model. Although the firm shows an average of only 56% prime performance across the warfare missions, nine of its twelve programs are characterized as "component development". Of the nine, seven are categorized as C2 development. The firm additionally established a commercial outlet for its component production and R&D. Raytheon's prime contract holdings are closely tied to its component and software strengths. Its value added performance is low in the DM and OMFTS warfare missions. Its performance in TAD and PS missions is moderate at 15 to 20%. Raytheon's strategy as a prime contractor appears to be two pronged. First, it is capturing prime contracts such as missiles, the Extended Range Guided Munitions (ERGM), and the Joint Tactical Radio System. These systems exploit Raytheon's ability to create hardened micro-electronic systems. The second prong attempts to capture a C2 architecture foothold similar to Northrop Grumman's in Sensors. The company has three programs (CEC, Patriot Pac III, LPD-17 IWS) that are key C2 elements for the OMFTS and TAD warfare missions.

A note on the Patriot PAC III, although the system is listed as a shooter, Raytheon's prime contractor performance is categorized as C2 development and integration. In the researcher's opinion, Raytheon's strategy places it a the follow the leader position for both prongs. In the component development track, the company has an exploitable niche, but is behind its commercial competitors in establishing economies of scale. In the C2 specialty, the firm is behind Lockheed Martin (which has a strong C2 capability supported by its interoperability economies.)

G. INDUSTRY ANALYSIS SUMMARY

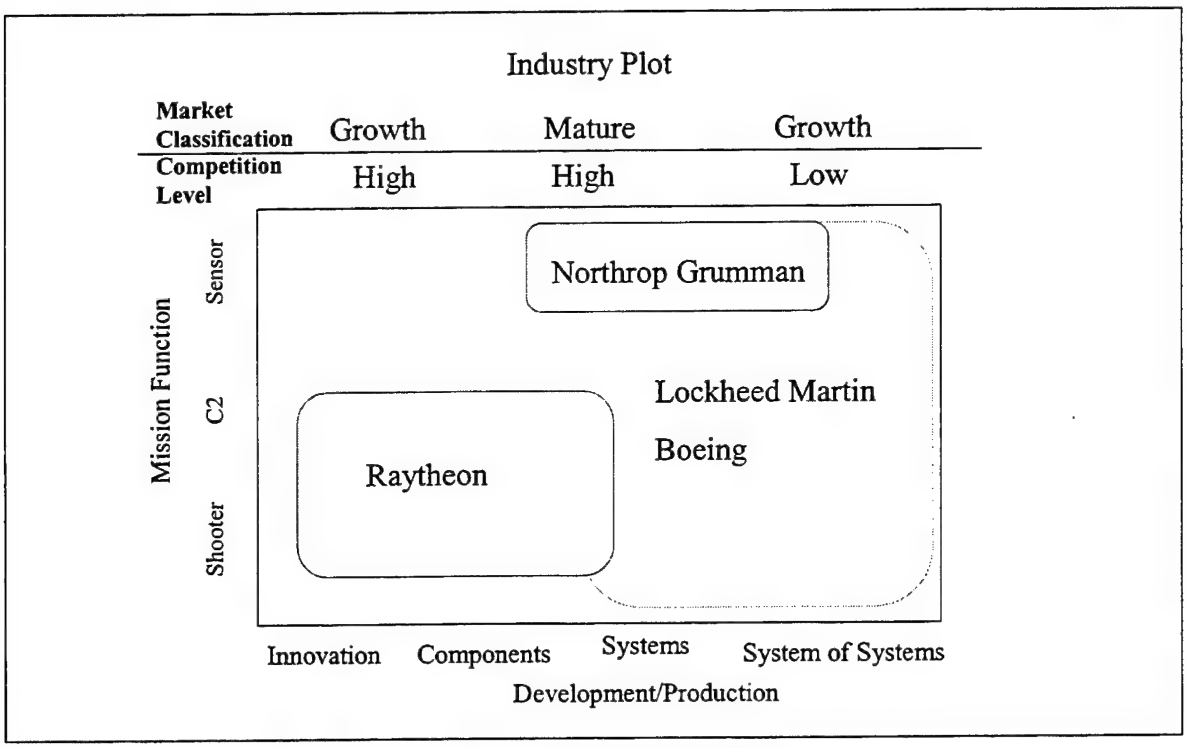

Figure 31 Industry Plot Developed by Researcher

Using a version of a market share plot, the researcher plotted the firms according to their position in the industry developing network centric warfare. Along the bottom of the chart are the three phases of the system of sytems value chain. The environmental

conditions at each phase are summarized in terms of market potential and level of competition. These are listed across the top of the plot.

The positioning of Boeing and Lockheed Martin suggests intense competition between the two firms. Both Firms appear to be using the same strategy. They are exploiting their design and integration abilities to expand system development presence across warfare missions. Their expansion is aimed at building an exploitable position for interoperability requirements. The researcher suggests that the difference between current conditions and where DoD leaders desire to be has more employment then these two companies can provide. Additionally, no other firms appear to have a near term capability to match theirs. Raytheon appears to have established a niche capability in a growth area by building integral components for Shooter and C2 systems. The niche, however, is a difficult position. The growth market at the component level is experiencing high competition due to the entrance of commercial firms with much larger R&D resources and economies of scale. Raytheon's component development skills have less value than interoperability production capabilities. It must compete against Boeing and Lockheed Martin's interoperability economies for fewer system development contracts. Therefore, competitive advantage from the right and the left of the plot will continue to increase market pressure on the Raytheon. Northrop Grumman has identified a solid niche in two highly valued areas of network centric warfare. By managing relationships with Boeing and Lockheed Martin, the firm is likely to protect its sensor niche and expand on its Unmanned Vehicle expertise.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The objective of this thesis was to establish a view of the DoD/industry relationship from the network centric warfare perspective. At the core of this perspective is the understanding that an integrated system of systems is the relevant market for traditional defense firms. This study applied a business model that framed the relationship in terms of complementary and competitive forces. Through this application, the study hoped to decipher the strategic intent of the industry's key **players**. It additionally hoped to validate the model's value and the importance of analyzing the industry in terms of the system of systems instead of platform development capability.

The value net model provides an excellent framework for organizing the influences on the relationship. Breaking the relationships down into groups of **key players**, **rules**, and **tactics** focused the research on significant factors affecting the relationship. The resultant sketch, although a simplification of many very complex entities, appears to capture a valid view of the essence and salient points of the relationship.

The data collected adequately supported the thesis' attempt to track the industry's movements towards capturing the network centric market. There are, however, shortcomings to the data set. First, the selection of the 78 programs was based on an outsider's view of the DoD's requirements process. The literature review provided an assessment of what the DoD's requirements officers are planning. It did not provide definitive statements as to the future systems of network centric warfare. In the

researcher's view the list has enough key programs to provide a sense of the requirement, it does not, however, provide a detailed or robust definition. Second, the unavailable data on prime contractor performance created underestimates in the value added calculation. Again, enough information was provided to garner a sense of the industry's intention, but a detailed accounting was not obtainable. Lastly, the analysis of the prime contractor's 1999 performance is a snap shot view. This analysis, although valuable, would have created a richer understanding of the industry if it were applied to earlier years and suggested strategic trends. The view of performance over time would have reduced the effect of the investment and production cycles attributed to weapon systems procurement.

These refinement issues aside, this thesis did validate the Value Net model as a tool for understanding complex industry relationships. It additionally identified broad market environment characteristics that are influencing the corporate strategies in the defense industry. It is apparent that Government and commercial forces are creating a growth market at the component level while simultaneously increasing the competition. Only one key industry player is indicating a desire to remain a competitor at this level. The platform or weapon system development market is maturing and gaining new entrants. This is creating stiffer competitions for smaller product lines. The product lines do not appear to be the value producer for this level of network centric warfare development. The close coupling of system architecture and operational doctrine is the key barrier to entry for the technology refreshment and interoperability markets. The key **players** will therefore remain active at this level as the attempt to leverage their involvement in the other two growing markets. Finally, the interoperability market has tremendous growth potential, with only two firms, Boeing and Lockheed Martin,

positioning themselves for general management roles. The last key player, Northrop Grumman, is establishing differentiation and niche market ability in the sensor lobe of the market.

B. RECOMMENDATIONS FOR THE DEPARTMENT OF DEFENSE

1. Recommendation #1

Conduct further studies assessing the Industrial Base in terms of network centric production capability with the Value-Net model.

This study identified valid points that suggest the traditional defense industry has identified the complementary value of linked weapon systems. They appear to be positioning themselves to use this value to increase their competitive advantage in satisfying DoD's requirements for technology refreshment and interoperability. The industry, therefore, should be analyzed by its production of network centric warfare mission capability instead of platform production capability. An analysis at this level will capture the complementary linkages and reveal potential attempts of foreclosure or forward integration.

2. Recommendation #2

Make a concerted effort to collect data that support Value Net Analysis.

The percentage of prime contractor performance is not centrally maintained and often difficult to gather. These data have relevance to the Value Chain analysis, which is pertinent to evaluations for new procurements and upgrade contracts. The data provide an insight into the importance of the prime involvement on the program. It may signal

opportunities for component breakouts or possible second sourcing. The compilation of the value chain data certainly provides a different view of the defense industry's viability. It has signaled to the researcher that certain firms are not going to fold if they lose the next aircraft contract. The researcher recommends DoD make a concerted effort to centralize data applicable to prime contractor performance.

3. Recommendation #3

Incorporate Value Net methods into market analysis training curricula for the DoD work force.

Both the Priced Based Acquisition report of December 1999 and the Defense Science Board Report on Vertical Integration and Supplier Decisions recommended that DoD personnel improve their industry and market analysis skills. The Value Net model is an excellent tool DoD personnel may use to improve their insights of industry situations ranging from the macro level study in this report to the environment around a single acquisition. Recommend the Value Net or a similar analysis tool be added to the training regime for DoD personnel.

C. SUGGESTED FURTHER STUDIES

This study provides only the basic level of strategic intent on the part of the key **players** in the defense industry. It does not fully discern the potential for foreclosure or the use of other anti-competitive tactics. Additionally, this study only looked at half of the network centric warfare picture. DoD is undergoing a revolution of business affairs,

which is integrating at an equally rapid pace. Suggested further studies that target these areas are:

1. Perform a trend analysis on the prime contractor's value added performance to detect the growth and shrinkage of market share for specific mission functions.
2. Plot the network centric linkages for the Revolution of Business Affairs and build a value net analysis of the key industry players involved in the sparing, distribution, contractor logistic support, base support programs. Then use the study to determine any strategic trends affecting the support of the revolution in business affairs.
3. Perform a study to determine the key overlaps between network centric warfare and network centric logistics and determine the implications for the prime contractors that support the overlap functions

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APPENDIX. DATA IN SPREADSHEET FORMAT

Program	Company	Sensor/C2/ Shooter	OMFTS	TAD	DM	PS	1999 Budget $M	Active K's $ M	% Prime performance
AH-1W@, *	Bell Helicopter	Shooter	X		X		27.6	1,016.0	UNK
V-22	Bell Helicopter	Shooter	X				460.0	2521.5	16%
Navstar GPS IIF	Boeing	C2	X	X	X	X	129	500.0	45%
AWACS RSIP	Boeing	Sensor		X	X	X	52.6	518.5	60%
Commanche	Boeing	Sensor			X		209.6	3,946.7	50%
DD-21 @1, *	Boeing	Sensor	X	X			7.9	67.1	UNK
LMRS@, *	Boeing	Sensor	X				35.9	82.0	50%
AGM-130@	Boeing	Shooter				X	0.3	0.0	16%
B-1@, *	Boeing	Shooter				X	287	28.8	UNK
Apache Longbow	Boeing	Shooter			X		633.7	2,100.0	67%
CALCM@, *	Boeing	Shooter				X	1.5	121.4	90%
AV-8B	Boeing	Shooter	X		X		377.9	609.0	40%
F/A-18*, #	Boeing	Shooter		X		X	3233.3	14,689.6	UNK
F-15E	Boeing	Shooter		X		X	300.8	8.6	80%
JDAM	Boeing	Shooter				X	135	528.4	25%
JSF *	Boeing	Shooter		X		X	118.5	662.0	UNK
SLAM*	Boeing	Shooter				X	58.2	0.00	90%
F-22	Boeing	Shooter		X			789.7	4,818.0	30%
V-22	Boeing	Shooter	X				609.8	3342.5	50%
MIDS FDL/LVT@	Datalink Solutions	C2	X	X	X	X	54.7	161.2	0%
SURTASS@, *	Digital Systems Resources	Sensor		X			272.3	13.7	UNK
Predator	General Atomics	Sensor	X		X	X	37.2	94.0	30%
SSN-21 *	General Dynamics	Sensor	X	X			183.4	40.0	UNK
AAAV	General Dynamics	Shooter	X		X		104.8	336.0	45%
DD-21 @1, *	General Dynamics	Shooter	X	X			28.3	183.6	UNK
DDG-51*, @1	General Dynamics	Shooter	X	X			1223.5	2,599.5	UNK
M1A2 Abrams	General Dynamics	Shooter			X		736.2	1,520.0	UNK
Virginia Class *, #	General Dynamics	Shooter	X	X			154.3	4,200.0	UNK

Tables 1 Master Spreadsheet 1

Program	Company	Sensor/C2/ Shooter	OMFTS	TAD	DM	PS	1999 Budget $M	Active K's $ M	% Prime performance
LHD@, *, **	Litton	Sensor	X				64.3	845.2	UNK
DD-21 @1, *	Litton	Shooter	X	X			27.1	186.6	UNK
DDG-51*, @1	Litton	Shooter	X	X			1680.8	3,570.9	UNK
LPD-17*	Litton	Shooter	X				492.3	1,400.0	63%
Advanced MILSATCOM*	Lockheed Martin	C2	X	X	X	X	54.4	2,400.0	UNK
CVN-77 IWS@, *	Lockheed Martin	C2				X	48.4	500.0	UNK
DMS	Lockheed Martin	C2	X	X	X	X	18.1	93.0	80%
DSCS	Lockheed Martin	C2	X	X	X	X	110.2	185.0	80%
GCCS-A	Lockheed Martin	C2	X	X	X	X	66.2	174.1	40%
MILSTAR	Lockheed Martin	C2	X	X	X	X	60.8	3,700.0	40%
Integrated Ship Defense@, *	Lockheed Martin	C2	X	X			18.9	90.3	25%
ADS@	Lockheed Martin	Sensor	X				47.1	104.0	80%
DDG-51 Aegis @	Lockheed Martin	Sensor	X	X			686.5	1,000.0	50%
NPOES*	Lockheed Martin	Sensor	X		X	X	7.0	20.7	UNK
P-3	Lockheed Martin	Sensor				X	258.8	272.9	30%
								not	
U2@, *, ^	Lockheed Martin	Sensor			X	X	9.6	released	UNK
FDS *, **, @	Lockheed Martin	Sensor		X			14.9	12.4	UNK
Future Scout *, @	Lockheed Martin	Sensor			X		22.55	148.0	UNK
SBIRS High	Lockheed Martin	Sensor		X			64.5	2,100.0	25%
Virginia Class C3I	Lockheed Martin	Sensor	X	X			72.5	205.0	70%
DD-21 @1, *	Lockheed Martin	Sensor	X	X			7.9	70.5	UNK
ATACMS	Lockheed Martin	Shooter				X	142.4	848.3	UNK
B-52 STLV	Lockheed Martin	Shooter				X	44.7	18.9	25%
F-14 Strike	Lockheed Martin	Shooter		X		X	236.6	259.0	50%
F-22	Lockheed Martin	Shooter		X			1603.4	9,782.0	19%
F-16	Lockheed Martin	Shooter				X	354.4	19,127.3	80%
JASSM *	Lockheed Martin	Shooter				X	3.8	2,075.3	68%
JSF *	Lockheed Martin	Shooter		X		X	92	719.0	UNK
MLRS	Lockheed Martin	Shooter			X		550.9	1,327.0	UNK
THAAD *, #	Lockheed Martin	Shooter		X			16	3,966.9	100%

Tables 2 Master Spreadsheet 2

Program	Company	Sensor/C2/ Shooter	OMFTS	TAD	DM	PS	1999 Budget $M	Active K's $ M	% Prime performance
CGS/JSWS	Motorola	C2	X	X	X	X	409.3	300.0	30%
CVN-77@, *	Newport News Shipbuilding	Shooter				X	190	346.1	UNK
E-2C Hawkeye	Northrop Grumman	Sensor	X	X		X	457.1	1,305.4	60%
EA-6B SLEP	Northrop Grumman	Sensor	X			X	141.1	595.0	93%
Global Hawk	Northrop Grumman	Sensor	X		X	X	76	659.0	50%
JSTARS	Northrop Grumman	Sensor	X		X	X	654.4	6,684.3	30%
TPS-75 *	Northrop Grumman	Sensor		X			196.5	108.5	UNK
B-2@, *	Northrop Grumman	Shooter				X	376.3	4,071.3	48%
AFATDS	Raytheon	C2		X	X	X	36.7	332.4	40%
CEC	Raytheon	C2	X	X		X	178.9	846.8	60%
GBS	Raytheon	C2	X	X	X	X	76	164.0	30%
LPD-17 Integrated Systems I, *	Raytheon	C2	X				140.6	266.7	UNK
JTRS@, *	Raytheon	C2	X		X	X	15.6	21.7	60%
Rivet Joint@, *	Raytheon	C2				X	230.8	0.0	UNK
Firefinder	Raytheon	Sensor			X		19.8	121.2	18%
Sentinel	Raytheon	Sensor		X			193.6	382.4	100%
SSDS	Raytheon	Sensor		X			61.2	140.7	90%
ERGM*	Raytheon	Shooter	X		X		27.5	600.0	UNK
ACM@	Raytheon	Shooter				X	1.4	37.0	50%
Harm Block 6 *	Raytheon	Shooter				X	36.1	100.0	50%
Patriot Pac-3	Raytheon	Shooter		X			271.6	706.0	97%
JSOW	Raytheon	Shooter				X	265.4	448.5	30%
Tomahawk	Raytheon	Shooter				X	497.8	322.5	49%
Standard Missile *	Raytheon	Shooter		X			70.2	1,561.6	60%
Commanche	Sikorsky	Sensor			X		158.2	2,977.3	0%
SBIRS Low *	Spectrum Astro	Sensor		X			269.2	275.0	UNK

Tables 3 Master Spreadsheet 3

Program	Company	Sensor/C2/ Shooter	OMFTS	TAD	DM	PS	1999 Budget $M	Active K's $ M	% Prime performance
FCBC2	TRW	C2			X	X	45	104.4	80%
Guard Rail	TRW	Sensor			X		62.3	1.0	UNK
SBIRS Low *	TRW	Sensor		X			269.2	275.0	96%
NPOES*	TRW	Sensor	X		X	X	7.0	20.7	UNK
Future Scout *, @	UDLP	Sensor			X		22.55	148.0	UNK
Bradley Family of Vehicles	UDLP	Shooter			X		361	524.0	33%
Crusader	UDLP	Shooter			X		313.2	2,000.0	16%
							23271.5	126,356.9	

@ = Used Army, Navy Air Force budget book to determine 1999 budget

@1 = Individual shares of 1999 budget calculated using contract award share % provided by Infobase Publishers DACIS database

^ = Multiple primes, but LM has such a large involvement considered for a Total System Program Responsibility contract.

* Total active contracts value calculated from Infobase publishers's DACIS database

Percentage of prime performance reported in infobase publisher's DACIS

! Computed value using % of total contract provided by Infobase and value of active contracts provided by the Program Integrator.

Tables 4 Master Spreadsheet 4

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
Navstar GPS	Boeing	C2	129	500.0	45%	58.1
AWACS RSIP	Boeing	Sensor	52.6	518.5	60%	31.6
DD-21 @1, *	Boeing	Sensor	28.3	183.6	UNK	UNK
F/A-18*, #	Boeing	Shooter	3233.3	14,689.6	UNK	UNK
F-15E	Boeing	Shooter	300.8	8.6	80%	240.6
F-22	Boeing	Shooter	1603.4	9,782.0	30%	481.0
JSF *	Boeing	Shooter	118.5	662.0	UNK	UNK
MIDS FDL/LVT@	Datalink Solutions	C2	54.7	161.2	0%	0.0
SURTASS@, *	Digital Systems Resou	Sensor	272.3	13.7	UNK	UNK
SSN-21 *	General Dynamics	Sensor	183.4	40.0	UNK	UNK
DD-21 @1, *	General Dynamics	Shooter	7.9	70.5	UNK	UNK
DDG-51*, @1	General Dynamics	Shooter	1680.8	3,570.9	UNK	UNK
Virginia Class *	General Dynamics	Shooter	154.3	4,200.0	UNK	UNK
DD-21 @1, *	Litton	Shooter	27.1	186.6	UNK	UNK
DDG-51*, @1	Litton	Shooter	686.5	1,000.0	UNK	UNK

Tables 5 Theater Area Defense Spreadsheet 1

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
Advanced MILSATCOM*	Lockheed Martin	C2	54.4	2400	UNK	UNK
DMS	Lockheed Martin	C2	18.1	93.0	50%	9.1
DSCS	Lockheed Martin	C2	110.2	185.0	80%	88.2
GCCS-A	Lockheed Martin	C2	66.2	174.1	40%	26.5
Integrated Ship Defense@, *, #	Lockheed Martin	C2	18.9	90.3	25%	4.7
MILSTAR	Lockheed Martin	C2	60.8	3,700.0	40%	24.3
DD-21 @1, *	Lockheed Martin	Sensor	7.9	67.1	UNK	UNK
DDG-51 Aegis @	Lockheed Martin	Sensor	1223.5	2,599.5	50%	611.8
FDS *, **, @	Lockheed Martin	Sensor	14.9	12.4	UNK	UNK
NPOES*	Lockheed Martin	Sensor	7.0	20.7	UNK	UNK
SBIRS High	Lockheed Martin	Sensor	64.5	2,100.0	25%	16.1
Virginia Class C3I	Lockheed Martin	Sensor	72.5	205.0	70%	50.8
F-14 Strike	Lockheed Martin	Shooter	236.6	259.0	50%	118.3
F-22	Lockheed Martin	Shooter	789.7	4,818.0	19%	150.0
JSF *	Lockheed Martin	Shooter	92	719.0	UNK	UNK
THAAD *, #	Lockheed Martin	Shooter	16	3,966.9	100%	16.0
CGS/JSWS	Motorola	C2	409.3	300.0	30%	122.8
E-2C Hawkeye	Northrop Grumman	Sensor	457.1	1,305.4	60%	274.3
TPS-75 *	Northrop Grumman	Sensor	196.5	108.5	UNK	UNK

Tables 6 Theater Area Defense Spreadsheet 2

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
AFATDS	Raytheon	C2	36.7	332.4	40%	14.7
CEC	Raytheon	C2	178.9	846.8	60%	107.3
GBS	Raytheon	C2	76	164.0	30%	22.8
Sentinel	Raytheon	Sensor	193.6	382.4	100%	193.6
SSDS	Raytheon	Sensor	61.2	140.7	90%	55.1
Patriot Pac-3	Raytheon	Shooter	271.6	706.0	97%	263.5
Standard Missile *	Raytheon	Shooter	70.2	1,561.6	60%	42.1
SBIRS Low *	Spectrum Astro	Sensor	269.2	275.0	UNK	UNK
FAAD C2I	TRW	C2	14.2	62.8	67%	9.5
NPOES*	TRW	Sensor	7.0	20.7	UNK	UNK
SBIRS Low *	TRW	Sensor	269.2	275.0	96%	258.4

Tables 7 Theater Area Defense Spreadsheet 3

TOTALS

Company	Active K's		1999 Segment Margin	1999 Value Added	Percent of Mission Performance	Percent of Mission contracts
Boeing	26344.3	811.3	9.8/6.1	741.0	25.5%	41.5%
Datalink Solutions	161.2	0.0	UNK	0.0	0.0%	0.3%
Digital Systems Resources	13.7	0.0	UNK	0.0	0.0%	0.02%
General Dynamics	7,881.4	0.0	12.0/10.6	UNK	0.0%	12.4%
Litton	1,186.6	0.0	13.0%	UNK	0.0%	1.9%
Lockheed Martin	21,410.0	1,115.7	8.8%	1017.2	35.0%	33.7%
Motorola	300.0	122.8	15.0%	104.4	3.6%	0.5%
Northrop Grumman	1,413.9	274.3	7.8%	252.7	8.7%	2.2%
Raytheon	4,133.9	699.1	15.1%	593.8	20.4%	6.5%
Spectrum Astro	275.0	0.0	UNK	UNK	0.0%	0.4%
TRW	358.5	267.9	26.5%	197.0	6.8%	0.6%
TOTALS	63478.5			2906.2	89.6%	84.0%

Tables 8 Theater Area Defense Spreadsheet 4

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's	% Prime performance	1999 Performance based earnings
AH-1W@, *	Bell Helicopter	Shooter	27.6	1,016.0	UNK	UNK
V-22	Bell Helicopter	Shooter	460.0	2521.5	16%	73.6
Navstar GPS	Boeing	C2	129	500.0	45%	57.4
DD-21 @1, *	Boeing	Sensor	7.9	67.1	UNK	UNK
LMRS@, *	Boeing	Sensor	35.9	82.0	50%	18.0
AV-8B	Boeing	Shooter	377.9	609.0	40%	151.2
V-22	Boeing	Shooter	609.8	3342.5	50%	304.9
MIDS FDL/LVT@	Datalink Solutions	C2	54.7	161.2	0%	0.0
Predator	General Atomics	Sensor	37.2	94.0	30%	11.2
SSN-21 *	General Dynamics	Active K's	183.4	40.0	UNK	UNK
AAAV	General Dynamics	Shooter	104.8	336.0	45%	47.2
DD-21 @1, *	General Dynamics	Shooter	28.3	183.6	UNK	UNK
DDG-51*, @1	General Dynamics	Shooter	1223.5	2,599.5	UNK	UNK
Virginia Class *	General Dynamics	Shooter	154.3	4,200.0	UNK	UNK
LHD@, *, **	Litton	C2	64.3	845.2	UNK	UNK
DD-21 @1, *	Litton	Shooter	27.1	186.6	UNK	UNK
DDG-51*, @1	Litton	Shooter	1680.8	3,570.9	UNK	UNK
LPD-17*	Litton	Shooter	492.3	1,400.0	63%	310.1

Tables 9 Operational Manuever From The Sea Spreadsheet 1

Advanced MILSATCOM*	Lockheed Martin	C2	54.4	2,400.0	UNK	UNK
DMS	Lockheed Martin	C2	18.1	93.0	50%	9.1
DSCS	Lockheed Martin	C2	32.1	185.0	80%	25.7
GCCS-A	Lockheed Martin	C2	66.2	174.1	40%	26.5
Integrated Ship Defense@, *, #	Lockheed Martin	C2	18.9	90.3	25%	4.7
MILSTAR	Lockheed Martin	C2	60.8	3,700.0	40%	24.3
ADS@	Lockheed Martin	Sensor	47.1	104.0	80%	37.7
DD-21 @1, *	Lockheed Martin	Sensor	7.9	70.5	UNK	UNK
DDG-51 Aegis @	Lockheed Martin	Sensor	686.5	1,000.0	50%	343.3
NPOES*	Lockheed Martin	Sensor	7.0	20.7	UNK	UNK
Virginia Class C3I	Lockheed Martin	Sensor	72.5	205.0	70%	50.8
CGS/JSWS	Motorola	C2	409.3	300.0	30%	122.8
E-2C Hawkeye	Northrop Grumman	Sensor	110.2	1,305.4	60%	66.1
EA-6B SLEP	Northrop Grumman	Sensor	457.1	595.0	93%	425.1
Global Hawk	Northrop Grumman	Sensor	76	659.0	50%	38.0
JSTARS	Northrop Grumman	Sensor	654.4	6,684.3	63%	412.3
CEC	Raytheon	C2	178.9	846.8	60%	107.3
GBS	Raytheon	C2	76	164.0	30%	22.8
JTRS@, *	Raytheon	C2	15.6	21.7	60%	9.4
LPD-17 Integrated Systems !, *	Raytheon	C2	140.6	266.7	UNK	UNK
ERGM*	Raytheon	Shooter	141.1	600.0	UNK	UNK
NPOES*	TRW	Sensor	7.0	20.7	UNK	UNK

Tables 10 Operational Maneuver From The Sea Spreadsheet 2

TOTALS

Company	Active K's	1999 Performance based Earnings	1999 Segment Margin	1999 Value Added	Percent of Mission Performance	Percent of Mission contracts
Bell Helicopter	3537.5	73.6	9.7%	66.5	2.7%	8.57%
Boeing	4,600.6	531.4	9.8/6.1	481.5	19.8%	11.15%
Datalink Solutions	161.2	0.0		0.0	0.0%	0.39%
General Atomics	94.0	11.2		11.2	0.5%	0.23%
General Dynamics	7,359.1	47.2	12.0/10.6	42.2	1.7%	17.84%
Litton	6,002.7	310.1	13.0%	269.8	11.1%	14.55%
Lockheed Martin	8,042.6	521.9	8.8%	475.9	19.5%	19.49%
Motorola	300.0	122.8	15.0%	104.4	4.3%	0.73%
Northrop Grumman	9,243.7	941.5	7.8%	867.6	35.6%	22.40%
Raytheon	1,899.2	139.5	15.1%	118.5	4.9%	4.60%
TRW	20.7	0.0	26.5%	0.0	0.0%	0.05%
TOTALS	41261.3	2699.2	1.0	2437.5	79.7%	57.6%

Tables 11 Operational Maneuver From The Sea Spreadsheet 3

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
AH-1W@, *	Bell Helicopter	Shooter	27.6	1,016.0	UNK	UNK
Navstar GPS	Boeing	C2	129	500.0	45%	58.05
AWACS RSIP	Boeing	Sensor	52.6	518.5	60%	31.56
Commanche	Boeing	Sensor	209.6	3,946.7	50%	104.823
Apache Longbow	Boeing	Shooter	633.7	2,100.0	90%	570.33
AV-8B	Boeing	Shooter	377.9	609.0	40%	151.16
MIDS FDL/LVT@	Datalink Solutions	C2	54.7	161.2	0%	0
Predator	General Atomics	Sensor	37.2	94.0	30%	11.16
AAAV	General Dynamics	Shooter	104.8	336.0	45%	47.16
M1A2 Abrams	General Dynamics	Shooter	736.2	1,520.0	UNK	UNK
Advanced MILSATCOM*	Lockheed Martin	C2	54.4	2,400.0	UNK	UNK
DMS	Lockheed Martin	C2	18.1	93.0	50%	9.05
DSCS	Lockheed Martin	C2	32.1	185.0	80%	25.68
GCCS-A	Lockheed Martin	C2	66.2	174.1	40%	26.48
MILSTAR	Lockheed Martin	C2	60.8	3,700.0	40%	24.32
Future Scout *, @	Lockheed Martin	Sensor	22.55	148.0	UNK	UNK
NPOES*	Lockheed Martin	Sensor	7.0	20.7	UNK	UNK
U2@, *, ^	Lockheed Martin	Sensor	9.6	not releas	UNK	UNK
MLRS	Lockheed Martin	Shooter	550.9	1,327.0	UNK	UNK

Tables 12 Dominant Maneuver Spreadsheet 1

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
CGS/JSWS	Motorola	C2	409.3	300.0	30%	122.79
Global Hawk	Northrop Grumman	Sensor	76	659.0	50%	38
JSTARS	Northrop Grumman	Sensor	654.4	6,684.3	63%	412.272
AFATDS	Raytheon	C2	36.7	332.4	40%	14.68
GBS	Raytheon	C2	76	164.0	30%	22.8
JTRS@, *	Raytheon	C2	15.6	21.7	60%	9.36
Firefinder	Raytheon	Sensor	19.8	121.2	18%	3.564
ERGM*	Raytheon	Shooter	141.1	600.0	UNK	UNK
Commanche	Sikorsky	Sensor	158.2	2,977.3	0%	0
FBCB2	TRW	C2	45	104.4	80%	36
Guard Rail	TRW	Sensor	62.3	1.0	UNK	UNK
NPOES*	TRW	Sensor	7.0	20.7	UNK	UNK
Future Scout *, @	UDLP	Sensor	22.55	148.0	UNK	UNK
Bradley Family of Vehicles	UDLP	Shooter	361	524.0	33%	119.13
Crusader	UDLP	Shooter	313.2	2,000.0	16%	50.10656

Tables 13 Dominant Maneuver Spreadsheet 2

TOTALS

Company	Active K's	1999 Performance based Earnings	1999 Segment Margin	1999 Value Added	Percent of Mission Performance	Percent of Mission contracts
Bell Helicopter	1016.0	0.0	9.7%	0.0	0.0%	3.29%
Boeing	7,674.2	915.9	9.8/6.1	828.3	49.3%	24.89%
Datalink Solutions	161.2	0.0	UNK	0.0	0.0%	0.52%
General Atomics	94.0	11.2	UNK	0.0	0.0%	0.30%
General Dynamics	1,856.0	47.2	10.6%	47.1	2.8%	6.02%
Lockheed Martin	8,047.8	85.5	8.8%	78.0	4.6%	26.10%
Motorola	300.0	122.8	15.0%	104.4	6.2%	0.97%
Northrop Grumman	7,343.3	450.3	7.8%	414.9	24.7%	23.81%
Raytheon	1,239.3	50.4	15.1%	42.8	2.5%	4.02%
Sikorsky	2,977.3	UNK	6.5%	0.0	0.0%	9.66%
TRW	126.1	36.0	26.5%	26.5	1.6%	0.41%
UDLP	2,672.0	169.2	18.3%	138.3	8.2%	8.67%
TOTALS	30835.2			1680.3	81.2%	78.8%

Tables 14 Dominant Maneuver Spreadsheet 3

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
NAVSTAR GPS	Boeing	C2	129	500.0	45%	58.05
AWACS RSIP	Boeing	Sensor	52.6	518.5	60%	31.56
AGM-130@	Boeing	Shooter	0.3	0.0	16%	0.0489
B-1@, *	Boeing	Shooter	287	28.8	UNK	UNK
CALCM@, *	Boeing	Shooter	1.5	121.4	90%	1.35
F/A-18*, #	Boeing	Shooter	3233.3	14,689.6	UNK	UNK
F-15E	Boeing	Shooter	300.8	8.6	80%	240.64
JDAM	Boeing	Shooter	135	528.4	25%	33.75
JSF *	Boeing	Shooter	118.5	662.0	UNK	UNK
SLAM*	Boeing	Shooter	58.2	0.00	90%	52.38
MIDS FDL/LVT@	Datalink Solutions	C2	54.7	161.2	0%	0
Predator	General Atomics	Sensor	37.2	94.0	30%	11.16
CVN-77@, *	Newport News Shipbuilding	C2	190	346.1	UNK	UNK
E-2C Hawkeye	Northrop Grumman	Sensor	457.1	1,305.4	60%	274.26
EA-6B SLEP	Northrop Grumman	Sensor	141.1	595.0	93%	131.223
Global Hawk	Northrop Grumman	Sensor	76	659.0	50%	38
JSTARS	Northrop Grumman	Sensor	654.4	6,684.3	63%	412.272
B-2@, *	Northrop Grumman	Shooter	376.3	4,071.3	48%	180.624

Tables 15 Precision Strike Spreadsheet 1

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
Advanced MILSATCOM*	Lockheed Martin	C2	54.4	2,400.0	UNK	UNK
DMS	Lockheed Martin	C2	18.1	93.0	50%	9.05
DSCS	Lockheed Martin	C2	110.2	185.0	80%	88.16
GCCS-A	Lockheed Martin	C2	66.2	174.1	40%	26.48
MILSTAR	Lockheed Martin	C2	60.8	3,700.0	40%	24.32
NPOES*	Lockheed Martin	Sensor	7.0	20.7	UNK	UNK
P-3	Lockheed Martin	Sensor	258.8	272.9	30%	77.64
U2@, *, ^	Lockheed Martin	Sensor	9.6	not releas	UNK	UNK
ATACMS	Lockheed Martin	Shooter	142.4	848.3	UNK	UNK
B-52 STLV	Lockheed Martin	Shooter	44.7	18.9	25%	11.175
CVN-77 IWS@, *	Lockheed Martin	Shooter	48.4	500.0	UNK	UNK
F-14 Strike	Lockheed Martin	Shooter	236.6	259.0	50%	118.3
F-16	Lockheed Martin	Shooter	354.4	1,000.0	80%	283.52
JASSM *	Lockheed Martin	Shooter	3.8	2,075.3	68%	2.584
JSF *	Lockheed Martin	Shooter	92	719.0	UNK	UNK
CGS/JSWS	Motorola	C2	409.3	300.0	30%	122.79
AFATDS	Raytheon	C2	36.7	332.4	40%	14.68
CEC	Raytheon	C2	178.9	846.8	60%	107.34
GBS	Raytheon	C2	76	164.0	30%	22.8
JTRS@, *	Raytheon	C2	15.6	21.7	60%	9.36
Rivet Joint@, *	Raytheon	C2	230.8	0.0	UNK	UNK
ACM@	Raytheon	Shooter	1.4	37.0	50%	0.7
Harm Block 6 *	Raytheon	Shooter	36.1	100.0	50%	18.05
JSOW	Raytheon	Shooter	265.4	448.5	30%	79.62
Tomahawk	Raytheon	Shooter	497.8	322.5	49%	243.922

Tables 16 Precision Strike Spreadsheet 2

Program	Company	Sensor/C2/ Shooter	1999 Budget $M	Active K's $ M	% Prime performance	1999 Performance based earnings
FAAD C2I	TRW	C2	14.2	62.8	67%	9.514
FBCB2	TRW	C2	45	104.4	80%	36
NPOES*	TRW	Sensor	7.0	20.7	80%	5.56

TOTALS						
Company	Active K's	Performance based	Segment Margin	Value Added	Mission Performance	Percent of Mission contracts
Boeing	17057.3	417.8	9.8/6.1	386.1	12.8%	29.3%
Datalink Solutions	161.2	0.0	UNK	0.0	0.0%	0.3%
General Atomics	94.0	11.2	UNK	11.2	0.4%	0.2%
Lockheed Martin	12,566.2	764.0	8.8%	696.6	23.1%	21.6%
Motorola	1,305.4	274.3	15.0%	250.0	8.3%	2.2%
Newport News Shipbuilding	595.0	131.2	12.5%	0.0	0.0%	1.0%
Northrop Grumman	25,160.0	1,516.9	7.8%	1289.8	42.8%	43.2%
Raytheon	1,093.7	374.5	15.1%	345.1	11.4%	1.9%
TRW	187.9	51.1	26.5%	37.6	1.2%	0.3%
TOTALS	58220.7			3016.3	90.1%	96.0%

Tables 17 Precision Strike Spreadsheet 3

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